

*On the occasion of ten years of ICPH activity (2000-2009), Dr. Massimo Teodorani sent us a long "Letter to the Editor", that we publish as received.
We thank the Author for this contribution to the open debate about instrumental methodology to be applied to the luminous phenomena in low atmosphere and for his special attention to Hessdalen-like phenomena.*

the editors

SCIENTIFIC INQUIRY ON ANOMALOUS ATMOSPHERIC LIGHT PHENOMENA: PAST RESEARCH GAPS AND NEW METHODOLOGICAL GOALS

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ABSTRACT. On the basis of the experience of this author, a decade of scientific research on earthlights is amply discussed and pondered from the point of view of instrumental measurements. After an introduction that shows a brief synthesis of what has been done so far, all the different measurement techniques and tactical/strategic procedures that have been used so far or that are planned for the near future are discussed in detail. Constructive criticism on the gaps that emerged from this research is punctually pointed out. New procedural ideas are widely proposed and scientifically motivated in order to improve this research and to stimulate researchers on this field in order to search for an optimum common protocol.

Keywords : astrophysics – criticism – data analysis - earthlight – electromagnetism – Hessdalen – instrumentation – methodology – measurement – physics – spectroscopy – strategy – tactics – theory – unidentified aerial phenomenon – VLF/ELF

Introduction

The recurrent behaviour of some anomalous atmospheric light phenomena such as “earthlights” (Il Laboratorio delle Anomalie, website; Long, 1990; Noguez, 2006; Odenwald, website; The Earth Anomalous Lightforms, website) has offered investigators an opportunity to study them scientifically. Experience lived directly on the field has furnished several teachings concerning the problems that are normally encountered in this research. This contribution is not specifically devoted to the description of scientific results obtained so far in this field but rather to the practical difficulties that a researcher encounters in trying to acquire scientific data using measurement instrumentation. No technical details will be furnished here. All the technical material has been already published and it is cited in the reference part of this conceptual paper, which might be intended more as an extensive “Letter to the Editor” than a research paper.

The *Italian Committee for Project Hessdalen* (ICPH, website), together with *Project Hessdalen* (website), has been promoting an important initiative during a decade, which has been almost entirely devoted to the attempt of acquiring scientific data of anomalous atmospheric light phenomena (otherwise called “earthlights”) using measurement instruments of several kinds through several research groups and individuals represented by physicists, engineers and experts. This has been realized by funding an amount of missions in the Norwegian area of Hessdalen, where instruments such as radars, VLF receivers, magnetometers and other sensors have been tested and installed by engineers and, occasionally, used by physical scientists. The ICPH initiative is unique as in previous stages this delicate field has been almost always characterized by the collection of witnesses using a ufological and/or merely descriptive approach. The collection of witnesses may be of some importance only if the data are accurate and/or in great number in order to allow one to obtain a good statistics that can, indeed, help researchers in doing some scientific steps (Teodorani, 2009b). Unfortunately, as well as in the general UFO or UAP cases, witnesses rarely furnish a kind of datum that can be considered objective: in

such a case data are affected by faults and, in many situations, by the misinterpretation of well known prosaic phenomena (Teodorani, 2008a; 2009a). That's the reason why measurement instrumentation can be considered at all effects an objective tool in order to document such phenomena, so that the scientific method can be reasonably put in practice, provided that the use of measurement sensors is not a sterile technological activity but rather the main facility that allows one to reason on data in order to search for something having in mind a clearly focussed goal. In general such an approach follows essentially three ways: a) data are obtained by impersonal instruments and not vaguely witnessed; b) if automatic instrumentation is used data can be acquired all the time so that the acquired statistics on phenomena can be considered reasonably objective and complete; c) data obtained using several kinds of sensors are subject to an analytic and comparative procedure in the attempt of finding a general law that may be reasonably deducible by many impartial observers.

Let's now see how and if such instrumented procedures of data acquisition worked in the proper way during this decade (Hauge, 2005). All the considerations that will follow will include mostly the work carried out by *Project Hessdalen* (Project Hessdalen, website), by the *Italian Committee for Project Hessdalen* (ICPH, website), by the *International Earthlight Alliance* (IEA, website) and by several other smaller groups some of which are located in Italy (45° G.R.U., website; CROSS Project, website; Devereux, 1982; Marfa Lights Research, website; Orbwatch, website; Progetto M.A.L.D.A., website; Rutledge, 1981; Sassalbo Project, website; Stephan et al., 2009; Straser, 2007; The Brown Mountain Lights, website; The Willard J. Vogel Study, website), including my own research work in this specific field. A lot of work has been done during all these years by almost all of the cited organizations and researchers, who are all motivated in this field.

Apart from a 7-years lasting project carried out in USA in the past (Rutledge, 1981), in Europe this research was started systematically by Project Hessdalen, which first, in 1984, demonstrated effectively that anomalous light phenomena are indeed measurable (Strand, 1984). This is allowed by the recurrent nature of such phenomena, which tend to occur frequently at specific areas of Earth: this favourable circumstance renders such locations a sort of "open air laboratory" where scientific research can be carried out. With no doubt the Hessdalen valley in Norway is the most famous of all of these locations, not just because it is the area in which anomalous light phenomena occur most often in the world but because it has been the first one that has launched a scientific/instrumented and long-term approach to the investigation of such phenomena. The implementation of an automated measurement platform in Hessdalen (Project Hessdalen, website) ten years ago has been the most logical continuation of that which started 15 years before (in 1984), when a quite varied and reasonably complete instrumentation was deployed and used directly on the field by expert personnel during a period of 40 days (Strand, 1984). The automation of measurement procedures that followed in subsequent years has increased the number of reported anomalous light phenomena occurring in the Hessdalen valley (Teodorani, 2004a), even if the automated station located there didn't constantly work. At the present time this measurement observatory (called "Blue Box") seems to work at a very limited rate, probably due to money funding problems or to other practical reasons that are presently unknown to me due to the end of any collaboration of me with the Norwegian researchers seven years ago. The quite recent praiseworthy initiative by Project Hessdalen researchers to organize "Science Camps" directly in the Hessdalen area, by involving students of several classes, has proved to be a very successful and wise way to stimulate youngsters to the scientific method using "mystery" as a motivational thrust and enthusiasm (Hauge, 2007; Strand, 2005; Skysurveyor, 2009).

A similar philosophy dedicated to instrumented data acquisition has been very recently adopted by ICPH through the SOSO automated video camera (SOSO Live Camera, website), which is currently recording successfully atmospheric phenomena of concrete scientific interest such as sprites, meteors and fireballs. This instrument is obviously very suitable to record light phenomena of whatever nature, and even if it has not yet been used at present in Hessdalen-like areas, it has been accurately and continuously tested and systematically used by monitoring more prosaic atmospheric phenomena from locations in the Centre-North of Italy.

The Hessdalen station has been soon joined by a quite powerful VLF-ELF receiver/spectrometer conceived and implemented by technologists of the INAF radio-observatory in Medicina (Bo), Italy (Cremonini, 2003; Ghedi, 2003), which has been recording automatically this kind of data during a few years. Radar equipment installed by the same group has been detecting occasionally some unidentified radar tracks (Montebugnoli et al., 2002). Other quite valuable specialists in the VLF-ELF field gave occasionally their contribution to the Hessdalen research (Gori, 2002; Radio Waves Below 22 KHz, website; Romero & Monari, 2005). New

instruments, such as an electric field detector (Gennaro & Giaiotti, 2004), have been tested in the area, and explorative missions have been carried out during quite severe weather conditions (ICPH, 2004). This has been a very useful and important exercise aimed at the optimization of measurement procedures directed to the scientific study of this very interesting phenomenon having in mind the goal of possible advancement and innovation of fundamental physics. Technical workshops have been organized as well (ICPH, 2006).

In Hessdalen many light events have been visually sighted and photographed with and without the use of spectrographic gratings. This, together with measurements of the electromagnetic field, has allowed the collection of a lot of information, some of which has permitted to describe quite accurately and quantitatively the physical behaviour of the light phenomenon (Teodorani, 2004a; 2008a). The Hessdalen research has been integrated by further scientific missions and field investigations carried out by non-ICPH scientific personnel in other parts of the world and in Italy (IEA, website; Teodorani, 2005; Teodorani, 2008a; Teodorani, 2009b; Teodorani & Nobili, 2004), while photographic and spectroscopic data coming from abroad have been carefully analyzed (Teodorani, 2004b; 2008a). Very detailed research projects have been published (Teodorani & Strand, 1998; Teodorani, 2000; 2001; 2009c; Teodorani & Nobili, 2006; 2007). New groups of scientific character that are devoted to the study of this kind of anomaly have been created and go on successfully (U.A.P.S.G., website). An accurate description of what is going on can effectively permit the construction of hypotheses and preliminary theories that might explain the way in which this physical phenomenon works (Derr, 1986; Freund, 2003; Fryberger, 1997; Ohtsuki & Ofuruton, 1991; Smirnov, 1994; Teodorani, 2004a; 2006; Turner, 2003; Zou, 1995), but so far no definitive physical theory exists yet; rather there seems to be an agreement among specialized researchers that anomalous light phenomena, according to their type, may be caused by several physical mechanisms and not only one (Teodorani, 2008a).

NARCAP (website), a very important scientific initiative is going on in USA since the year 2000, being devoted to the study and evaluation of possible dangers to aviation caused by unidentified aerial phenomena (UAP), including earthlights or Hessdalen-like phenomena. This author is quite actively collaborating with this organization as a research associate since a few years (Teodorani, 2009c).

Hoaxes have been often unmasked in order to attempt to stimulate scholars to a more effective critical thinking and prosaic explanations have been quite successfully furnished of light phenomena that were previously considered anomalous (Teodorani, 2009a; Pettigrew, 2003; Project Sassalbo, website).

In the light of the past and present research experience on the field we should now analyze critically how and if our instrumented approach in studying anomalous light phenomena can be considered effective and how much it has been such. Let's try to examine this according to the kind of measurement instruments that have been used more often both in the form of fixed stations and in the form of missions on the field. Of course, in this discussion, the Hessdalen research will be considered mostly. All that which will follow next is not a dogmatic imposition, of course. It is my own way to see objective facts coming from my own experience and from my observation of the work carried out by other researchers, but I think it might stimulate a debate or maybe trigger different opinions: they are welcome, if a constructive purpose is really what we all aim at.

1. Video monitoring

Video cameras are probably the most used tool in order to document anomalous light phenomena. Automated video cameras such as the ones that constitute the main equipment of the "Blue Box" in Hessdalen, or (even better) of the SOSO camera that is presently used in Italy, have allowed to capture several light anomalies and atmospheric electric events of interest, after a proper screening was done among all the other light sources. This kind of data is very useful to acquire kinematical data on the anomalous light phenomena and to check their variability in luminosity and colour. Most importantly video data are able to permit to obtain reasonably realistic statistics on the phenomenon occurrence, but, concerning the Hessdalen case, such a performance has been limited to a time lapse ranging from 1998 to 2002 (Project Hessdalen, website). Nevertheless, not more than the described information can be acquired using a video system. Video snapshots are always of too low resolution to permit to carry out analytical work. In the specific case of Hessdalen the automated video camera system has been working full time for a very few years, then it then went into failure due to several technical problems. Of course this is not certainly the fault of technologists controlling this apparatus. The video system

that is presently used works in streaming so that no recording is possible; in the form of now this system is just a simple “window” on the Hessdalen valley. These limitations are partly due to lack of funding and partly to practical problems that may occur in the area. In any fact the monitoring station as it is now seems to work as a “test bed” that is used mostly for teaching purposes, such as student’s exercises and master theses dedicated to the subjects of electronic engineering and informatics. No real science can be at present extracted from the present video system’s configuration, even if in the past the Blue Box has permitted to obtain a quite useful statistics concerning anomalous light phenomena (Teodorani, 2004a).

Much better results have been obtained more recently by the SOSO camera (SOSO Live Camera, website), which is presently monitoring all the time the sky from a location close to Bologna, Italy. In the specific case of SOSO, which so far is able to capture atmospheric sprites and bolides, what is acquired by the video camera is quite easily recognizable. A similar approach is presently used by a monitoring station in the Marfa area in Texas (Marfa Lights Research, website), which anyway is also devoted to videoing ascertained anomalous light phenomena occurring very recurrently in the area. Light phenomena of anomalous nature may not be recognizable as such if simple “light balls” are captured at night time by a video camera. Light phenomena of such an unstructured nature might be in some circumstance mistaken for airplanes turning and/or landing, helicopters or even “Chinese lanterns”, unless characteristic erratic features of motion are recorded (this is sometimes, but not always, a typical signature of earthlights). Several signatures are necessary in order to recognize an earthlight that appears in a video and a quite strict screening is often necessary in order to exclude ordinary causes (Project Hessdalen, website). Anyway the performance shown (also in terms of efficiency, including some triangulation efforts) by the SOSO system seems to be presently superior to the one shown by the standard Hessdalen station, so that a possible implementation of the SOSO camera in Hessdalen and other interesting areas is highly recommended if money funding will allow this in the near future.

In conclusion, a video system furnishes – continuously and automatically – some information that may be of some scientific interest, in particular: documentation, light and colour variability, kinematics, statistics and time-correlation with data furnished simultaneously by specialized electromagnetic instruments. But, due to its limited nature, it doesn’t allow researchers to carry out a really analytic work in terms of image analysis. This can be possibly just partially obtained only using professional and quite expensive video cameras that are occasionally used on the field, such as during the EMBLA 2001 mission (Teodorani, 2004a). All this said, it can be declared that videoing anomalous light phenomena has been, during a decade, a quite well experimented activity both using fixed stations and occasional missions on the field (45° G.R.U., website; CROSS Project, website; IEA, website; Progetto M.A.L.D.A., website; The Brown Mountains Lights, website; The Willard J. Vogel Study, website). The videoing technique can acquire a solid scientific relevance from the analytic point of view mostly if it is joined with electromagnetic instruments that, working simultaneously with video monitoring, acquire data continuously: in such a case important time-correlations may be established and some important science can be derived. This result has not been achieved so far.

2. Photographic recordings

Conventional and digital reflex cameras, though not showing the time dynamics of the phenomenon, can allow a much higher resolution than simple video snapshots. From this a quite accurate image analysis is possible. In particular, professional digital reflex cameras offer clear advantages due to the high integration speed of the CCD sensor. This can be highly advantageous when an anomalous phenomenon is approximately standing still in the sky or close to the ground. If the light phenomenon is moving (in the sky or close to the ground) a photograph of any kind shows only a trail of very scarce utility as scientific information. It happens often, to inexperienced observers, that moved frames are mistaken for “structures” of the object. The trails may be useful sometimes, but in such a case an analytic approach can be used only rarely.

Hessdalen lights are often standing still, very close to the ground and more rarely in the sky (Skysurveyor, 2009). This has permitted to obtain some interesting photos (Project Hessdalen, website; Teodorani, 2004a) from which some analysis has been possible. The derived Point Spread Function of such light phenomena has shown some characteristics of scientific relevance, including the “clustering effect” which seems to characterize this kind of phenomenon (Teodorani, 2004a; 2008a; 2009c) and the approximate identification of

the phenomenon as plasma. Sequential photographs have shown quite clearly the effects of light, colour and shape changes. All this means that an apparently simple or naive tool such as photography (assuming that it is obtained using professional equipment together with high-quality zoom lenses) can be able to furnish some scientific results. But this is clearly dependent on the presence of personnel in the area. Such a task cannot be achieved, in general, using an automated system. Experience acquired from several missions carried out in Hessdalen and elsewhere shows that if well-prepared and careful personnel is constantly present on site for at least two weeks some probability to capture something of interest does exist. But this depends on the constancy of the personnel and on his/her ability to promptly recognize anomalous lights from ordinary lights. If earthlights, differently from the ball lightning case, lend themselves to be photographed due to their tendency to stand still for a sufficient long time, they show anyway a serious disadvantage as well: due to the fact that they often tend to appear, to an inexperienced observer, close to the ground they can be inevitably confused with cottage lights, car headlights, turning or landing airplanes and other prosaic light sources (Teodorani, 2008a). Therefore, before a monitoring mission is carried out it is absolutely necessary first to identify all the sources of perceptive error such as the ones cited above. This has been constantly done in Hessdalen by my group and myself in the course of all of the three explorative missions to which I took part, and of all the other missions abroad and in Italy that I carried out together with my collaborators (Teodorani, 2004a; 2005; 2008a; 2009b; Teodorani & Nobili, 2004). Roads and cottages position were identified and quite carefully noted as a reference point, including the position of luminous planets and/or stars that are very low on the horizon. Airplane passage and light manifestation was constantly monitored. The same was done during the mission to Arizona in 2003 (Teodorani, 2005), where, except for some still unexplained lights, many were identified as ordinary lights, some of which caused by refraction/mirage effects of various nature, night birds and other causes: the acquisition of optical spectra of all the suspected prosaic lights helped a lot in this task. Clearly who wants to diagnose a genuine earthlight must have a perfect knowledge of all the causes of “noise” overlapping on the “signal”. Certainly this is not always easy, but at the end it has been realized by most serious researchers operating in this field. This procedure has helped also to lower the reliability level of testimonial cases, which in many cases can be explained as ordinary lights seen in particular atmospheric and/or perspective conditions (Pettigrew, 2003; Teodorani, 2008a).

Doing this research is not easy at all: in practice this is like to search for gold nuggets within a great amount of stones. Being true that an automatic measuring station equipped with video cameras offers a much larger probability to obtain data, it is also true that the absence of specialized personnel on site doesn't permit to obtain results of a really scientific valence. In few words this research costs much sacrifice, patience and experience, as it is very similar to bird hunting or watching. This means that scientific personnel must be sufficiently ready and willing to pass many hours of the night watching outside and keeping instruments turned on and on an alert state: regarding this the Norwegian “Science Camps” are a very instructive initiative (Strand, 2005). The presence of specialized personnel on site working with their own portable instruments may offer better results than an automated video camera system, unless the automated system is working simultaneously with equipment able to measure the electromagnetic field all the time. An automated system should be always a complementary option to be added and not replace the presence of personnel on field.

3. Image intensification and infrared recordings

Some filters for near-infrared photography (such as the Wratten 87) attached to digital reflex cameras cannot be used at night due to the prohibitive exposure times that are needed. They can be used efficiently at daytime. No results have been obtained anywhere by my group using this technique (Teodorani, 2009b; Teodorani & Nobili, 2004) and no evidence of “low-energy plasmas” appearing at daytime has been obtained so far. Some results in this sense have been apparently obtained recently in the Northern Apennines by other observers such as astronomy amateur Nicola Tosi of Project M.A.L.D.A., who used another kind of infrared filter (Project M.A.L.D.A., website), and also added (alternatively) an H Alpha filter for astronomical photography: these filters seem to enhance a light phenomenon that is seen optically and/or to detect what the optical range doesn't. This technique should be certainly used more often in this research.

Specific infrared film for conventional photography is quite unpractical to be used in these circumstances (earthlight monitoring), and, at the best of my knowledge, it doesn't seem that relevant results have been obtained so far by any group devoted to such research.

Image intensification using “night vision systems” can be just useful as an alert tool but not scientifically effective, unless it is attached directly to a recording camera. Today, it is anyway almost useless due to the present availability of the “night shot” option in present video cameras.

The best system able to offer a real scientific potential is constituted by thermal imaging cameras or similar sensors obtained using custom built instruments. In addition to operating in a farer region of the infrared spectrum, such cameras, if properly equipped with powerful zoom lenses, can allow to disclose and record continuously what the eye (together with optical cameras) cannot see. This doesn't mean that all that which is captured by a thermo camera is an “UFO” or an earthlight (it can be everything, including birds or insects), but certainly it increases largely our capability to get a complete description of the phenomenon under study and, above all, to evaluate how long are the times in which the plasma phenomenon (or else) is existing in the various wavelengths. For instance, if a thermo camera is used simultaneously with a portable radar and/or with electromagnetic and magneto metric equipment, it may help to identify (especially if the multi-wavelength phenomenology is recorded simultaneously) the source of some possible unidentified tracks recorded by the radar, of some signals recorded by a VLF-ELF or UHF spectrometer, or some disturbances occasionally recorded by a magnetometer. A thermo camera is the best tool to look into the invisible having the capability to resolve spatially the target and also to show possible intensity variations. But it is a very expensive instrument and not easy to bring abroad without passing for a threat due to the fear of terrorism and the consequent strict controls at airports. Tactically such kind of sensor, which can anyway be rented for one or two weeks, should be intended to be used in the same country where it has been rented or bought. It seems to me that such sensor has never been used for research on earthlights. A similar, custom built, equipment is occasionally used in “UFO” research (Avila, 2006), by showing effectively several targets that are normally invisible, which unfortunately are not yet interpreted in a sufficiently equilibrated way due to the “need to believe” of whom is using it. But the aptitude can change, while the availability of such equipment is surely a good result, which should be extended to the study of earthlights as soon as possible. It may be declared with surety that a thermal imaging camera is potentially one of the most important sensors for the study of earthlights: unfortunately the quite poor money funding availability for this research (for most groups, including mine) is the discriminating factor that decides if important discoveries can be done or not, and this is quite sad.

4. Optical spectroscopy

This is a quite delicate subject, which must be discussed very thoroughly, especially in the light of the past experiences had by some researchers (Project Hessdalen, website; Hauge, 2007; Marfa Lights Research, website; Orbwatch, website; Stephan et al., 2009) and by myself and/or in collaboration (Teodorani, 2004a; 2004b; 2005; 2009b; including still unpublished results obtained at some Italian locations).

Spectroscopy can in principle furnish very important information from the physical point of view. In some way, spectra are in themselves a sort of “identity card” of an excited/ionized gas or plasma. Earthlights are strongly suggested to be plasma formations (Teodorani, 2004a). If some gas is excited it is possible to identify spectral lines which may furnish a decisive information both on the temperature and on the chemical composition of the plasma, and, sometimes also (most importantly, as it will be seen later) on the magnetic and electric fields that may be generated therein, and other effects such as plasma rotation and turbulence. If the gas is totally ionized we normally see a continuum spectrum, which is totally devoid of lines: after knowing the sensitivity curve of the used sensor or film, it is possible to measure the plasma temperature from the continuum spectrum by using the classic Planck theory (Lang, 1998).

Important information such as the spectroscopic one can be obtained at a quite low price using a dispersion grating of sufficiently high resolution and high quality, and attaching it to a high-resolution camera using the different ways that are allowed. A quite rich procedural know-how has been acquired by this author in the course of at least 10 missions to areas where light anomalies occurs. The acquired experience has permitted to choose the right focal length to obtain a well resolved spectrum and a series of tactics to adopt in order to obtain a high quality spectrum in the shortest possible time. The very most part of the spectra obtained so far have been easily explained as due to ordinary lights, in fact spectroscopy is an optimum tool to identify the nature of lights. A quite rich databank concerning spectra produced by known light sources has been quite

accurately prepared in the course of the years (Teodorani, 2008a): such spectra can be used both as wavelength calibration reference facilities and as identification tools. The spectrum obtained using a transmission grating attached to a camera can be diagnosed visually and/or documented photographically if it is judged of sufficient interest or if sufficient exposure time is feasible. Very few of the obtained spectra showed some real anomaly, on which a physical discussion has been done (Teodorani, 2004a).

The way in which optical spectra are obtained is decisive. Common sense and experience on the field shows that obtaining a spectrum and a photo of a light anomaly in the same frame (Project Hessdalen, website; Hauge, 2007; Marfa Lights Research; website; Orbwatch, website), is rarely effective for a scientific study. Spectra obtained this way, due to the used short focal length, furnish a too low resolution to allow a researcher to perform on them a really serious study. Certainly this is the easiest way to obtain spectra and in the shortest time, but it is not at all the best one. Clearly due to the very short reaction times between the apparition of a light phenomenon and the acquisition of a spectrum, it is not easy at all to use long focal lengths in order to obtain well resolved spectra. This procedure requests for a bit more time due to a necessary slight movement of the camera to the left or right side of the light target. In many occasions this cannot be done quickly enough due to the limited available time, if the light phenomenon is short-lasting. Therefore one must be content of this easy but very low-quality procedure. Nevertheless, in most of the cases a spectrum of this kind will be of almost zero utility scientifically, unless very strong (but unsaturated) emission lines are present. In conclusion, experience shows that a photographic frame containing both the light and its spectrum is much easier to obtain and it is an operation in which the probability to obtain the spectrum of the light of interest is the highest, but the result is always extremely poor (see Fig. 1), often totally useless.



Figure 1. Spectra of streetlights (Mercury vapour lamp) used as reference spectra for wavelength calibration. A. Very low-dispersion spectrum taken in 2007 by Norwegian researchers in Hessdalen using a conventional *Canon A-1* reflex camera attached to a 50 mm lens and to some kind of grating (Hauge, 2007). B. Much higher dispersion spectrum taken by this author using a *Fujii Finepix S-2 Pro* professional reflex digital camera attached to a 70-300 zoom lens and to a ROS (Rainbow Optics Spectroscope) holographic grating (Teodorani, 2008a). The same emission lines are compared together in order to show the big difference in spectral resolution.

A photographic frame containing only the spectrum of interest, elongated by a long used focal length is a more difficult task to reach, but practice shows that such an operation can be quite quickly feasible if the light phenomenon is lasting for a sufficient long time (this happens quite often with earthlights). The result is always good and the spectrum, whatever causes it, can be effectively used for doing science (Teodorani, 2004a; 2004b; 2005; 2008a). A higher resolution spectrum permits a much better pixel-wavelength calibration and consequently a better identification and quantitative analysis on spectral lines, if present. In such a way spectral diagnostic is a sure and safe fact, on which it is really possible to build up a physical interpretation that is able to hold water.

Spectroscopy is an operation that requests for a quite deep experience in the field which only a specialized physicist or an astronomer has: they should be consulted more. Sometimes, due to some specializations, also engineers have this kind of experience (Stephan et al., 2009), in most other cases not. A spectral line must be recognized and identified with maximum surety, while tentative identifications amidst a forest of background noise in a very-low resolution spectrum is scarcely advisable (Hauge, 2007; Teodorani, 2008b). A spectral line has its own appearance with a very specific FWHM (Full Width at Half Maximum). Before thinking to have found or identified a spectral line in a spectrum it should be considered that some “spikes” that are apparently seen in the spectrum may be simply the fluctuating effect of pure noise if these “spikes” are not at a level of at least 3σ error (optimum is 7σ) over the noise level (this can be seen by doing a comparison with the background level), unless the same suspected feature occurs at the same pixel position in more than one spectrum taken using the same resolution and not only one. Anyway spectral analysis software should be used

more critically and not rigidly, especially when spectro-chemical identification is carried out. For instance, if an interactive spectral line database is over plotted with a wavelength calibrated spectrum, this procedure of identification is not safe at all for two reasons: 1) many of the alleged spectral lines are not lines but noise fluctuation; 2) if the wavelength calibration is not accurate at a 100% level a spectral line (if really present) can be mistaken for another one due to a wavelength error. Let's not forget, in fact, that chemical elements producing spectral lines are very many: we can find, on average, three lines for each Ångström, while wavelength calibration errors may be of the order of 5-10 Å in very low-resolution spectra.

Together with a not sufficient amplitude (3σ over the noise level, at least) of the suspected spectral line, if the wavelength calibration is not perfectly accurate (inaccuracy in wavelength calibration is always typical of very-low resolution spectra) the identification of a spectral line of an alleged chemical element may be very tentative or wrong. If a spectral line produced by a given chemical element of specific ionization and excitation state (Hertzberg, 1944; Lang, 1998) is really present it must be shown not only at one wavelength but also at several other wavelengths according to the different energy levels that can be acquired. In a real plasma (such as in stars) if we have a line spectrum, lines of a chemical element of specific excitation must be more than one. The presence all over the entire spectrum of different wavelengths at which the same excited chemical element manifests is a good indication of the goodness of line identification even if wavelength calibration is not accurate due to low resolution. Whatever is the pixel-wavelength calibration error the difference in wavelength between such lines must be the one that is predicted by quantum theory for those lines: this means that the spectrum might need a wavelength correction, namely a wavelength shift forwards or backwards while the difference of central wavelength of these lines remains obviously the same.

Moreover, alleged lines that are singled spikes might be very suspect due to some defects in the used film or to hot/cold pixels of CCD camera. Before a spectrum is subject to the procedure of line identification, after wavelength calibration using a reference spectrum is carried out, a check of possible anomalies must be done together with digital cosmetics, if necessary. On the contrary any possible identification of a spike with a spectral line is inevitably a mistake, which then manifests very seriously in the physics that is deduced subsequently. This is what may happen sometimes, but not necessarily in specific cases (Hauge, 2007).

Flux calibration (using a known source such as a star like Vega) is a fundamental operation if one wants to derive the (colour) temperature of a plasma target, but it may be, wholly, an unnecessary operation if one wants to concentrate the analysis on spectral lines (if a given spectrum contains lines effectively). Analysing spectral lines doesn't only mean to identify them but also to determine quantitatively how much energy they extract from the continuum (Lang, 1998; Teodorani, 2004b). Assuming that spectral lines are correctly identified, this operation is only possible if the spectrum is normalized to unity, by dividing the spectrum by an interpolating function of a certain order. After further operations are carried out, this can bring realistically to the number of atoms that contribute to the production of a given spectral line (if really present). This and only this can lead to the construction of a physical model describing the atomic state of the investigated plasma.

And now let's discuss "spectra of earthlights". Experience shows (The Brown Mountain Lights, website; Teodorani, 2004a; 2008a) that, in reality, such spectra do not represent at all the identity card of a plasma, as such spectra may change (presence or absence of certain lines) according to where the plasma is activated and to the temperature of the plasma itself at specific times. If it occurs in the sky we might expect simply excited atmospheric lines, whose intensity may vary according with the air density at a given time. Aerosol lines might be transiently present and sometimes not. If the plasma occurs close to the ground it might excite elements that are on the ground or over it, such as dust made of several chemical elements, such as silicon for instance, or it might trigger strange effects if other elements such as mould spores are present (Teodorani, 2004a), which might be more abundant in specific places than in others.

According to the few collected data so far in terms of optical spectroscopy the plasma itself doesn't highlight specific chemical elements other than the surrounding ones that are transiently excited by its field of force (of which we do not well yet the nature, but on which we can so far venture work hypotheses). Earthlights are not at all like stars when we consider their "photosphere": their spectrum may change all the time, and they may not offer relevant physical information on the intrinsic nature of the plasma, unless we analyze the specific shape of spectral lines. In particular, if spectral lines are split symmetrically we may suspect the presence,

inside the plasma, of a more or less strong magnetic and/or electric field producing respectively Zeeman and Stark effects (Lang, 1998). This may be the physical information that can be really important if we want to build up some physics from the spectroscopic observation of earthlights such as the Hessdalen ones. If the plasma is spinning fast we might also find the signature of a rotational broadening effect of spectral lines (in case mixed up with a turbulence effect): this might be another signature of real physical importance that must be considered in this research. In order to record such features of spectral lines we absolutely need that the spectrum is of sufficiently high resolution. On the contrary these features will not be visible and/or analyzable at all with sufficient accuracy.

High-resolution doesn't mean at all using a multi-order "echelle"-like spectrograph (Lang, 1998), for instance: high spectral resolution would be of course ideal for this kind of research, but experience (Teodorani, 2005) shows that: 1) if the light under study cannot be passed through a slit the spectrum cannot be acquired: this happens always if the light moves and/or cannot be properly tracked using some means (radar and/or CCD camera); 2) even if the light can be accurately tracked the particular nature of very high-resolution spectroscopy (of the echelle kind) creates spectral orders that are very weak in luminosity: this means that nothing can be recorded of the spectrum, unless one is able to use an image intensifier by attaching it to the spectrographic device (at the expense of the weight of the entire optical system); 3) integration time might be obviously increased in order to permit the acquisition of enough photons to render a given spectral order visible but this can be done only if the phenomenon is still visible during exposure; 4) in general present echelle high-resolution spectrographs allow to acquire spectral orders separately (typically 10 or 20), and this takes more time in the entire operation: this shows once more that the use of echelle spectrographs is totally unpractical (in addition to being very expensive) in order to accomplish the task of studying physically earthlights. These factors, which have been tested by past experience (Teodorani, 2005), show that high-resolution spectroscopy in the proper sense of the term, at the present state of our optical technology, cannot be used for this specific research. Quite good advanced systems have been used recently (Stephan et al. 2009).

So let's go back to the point regarding the necessity of taking spectra of "sufficiently high resolution". What does it mean? It means simply what has been told before, namely just a practical compromise. We cannot make without using a transmission grating (attached to a conventional camera, to a professional digital camera, or to an astronomy-like CCD camera), which cannot allow one to obtain a really high spectral resolution. But this practical choice can be optimized by attaching a transmission grating to a camera (possibly a professional digital camera) that is equipped with a zoom lens that permits to obtain sufficiently long focal lengths. Long focal lengths are able to record a few Ångström per pixel, which gives much better resolution than many Ångström per pixel. The technique to obtain this has been described before: some exercise can permit to optimize the acquisition operations in order to reach this task successfully. Regarding this, it must be once more stressed that a spectrum acquired using a short focal length (typical of photographs that portray both the light under study and its spectrum) is almost totally useless, unless very strong spectral lines are present and easily identifiable. In general taking this kind of spectrum is time lost, and the effort to analyze it may be both time loss and the source of inevitable errors.

The use of an optical configuration comprising a telescope, an astronomy-like CCD camera and its acquisition computer, is another source of time loss if a given "light ball" is not stationary and if the telescope cannot be easily and accurately tracked to the target. Certainly if the target is approximately stationary this procedure can furnish optimum results (it can rarely happen) (Stephan et al., 2009), but unfortunately earthlights (when they move) cannot be tracked by simply synchronizing the telescope tracking engine with Earth rotation, because they are not simply stars. Earthlights are often characterized by a random motion, but they can be or appear also stationary for a certain time; or they can move but being very far and luminous they can offer a very good circumstance to take a spectrum of them without any tracking is done due to the very small angle through which the light movement is seen. In general, a simple digital professional camera should be preferred to a telescope, due to the much larger view field of such a camera compared with a typical telescope view field. In few words if we use a telescope instead of a camera, except for the specific cited case above, there is a high probability that if the telescope is not accurately tracking it, the light goes out from the view field rendering any spectroscopy impossible. Therefore the past experience shows that the choice of a 35 mm digital camera connected to a transmission grating used at its highest resolution, is the most practical and effective solution if one wants to limit the analysis to spectral line identification and morphology, of course in the hope that spectral lines are effectively produced at the time of the plasma ball apparition.

If a plasma ball or whatever is moving but is very luminous and long lasting, tracking to the target can be unnecessary. This is a quite favorable circumstance that may occur in Hessdalen too (Hauge 2007), especially if the sighted phenomenon is quite close to the observer. Several spectroscopic tests carried out on airplanes (Teodorani, 2009b), without using any tracking system shows that all the positions at which the light source is moved produce an independent spectrum. If the light source is sufficiently luminous only one of these spectra may be sufficient for analysis. If the light source is weakly luminous and if the extremes of the recorded spectra are well identifiable, it is possible to align (by software) them all and sum all together, so that the signal-to-noise ratio becomes favourably increased in order to carry out a good analysis. In general it must be recognized (as a wise strategy) that if the light phenomenon is very luminous (so that we do not need to sum the spectra together) and is moving, we have a very important opportunity to study possible time variability of spectral features with time and verify, for instance, if such a variability depends on parameters such as acceleration, luminosity/color increase, if a video camera is used at the same time. This can be, physically, extremely important, and a result of this kind can be obtained using mainly a very portable spectrographic system constituted by: 1) a professional digital camera characterized by high spatial resolution (in megapixels), wide field, high dynamic range and very high sensitivity of the CCD sensor for weak light intensity targets; 2) a high-quality zoom lens of the class 24-300 mm; 3) a high-quality transmission grating, that can be simply applied on the lens. Unless one wants to carry out specific procedures, in the case of earthlights there is no real necessity to use telescopes or astronomical CCD cameras. And if the data are of good quality then it is the analysis procedure that becomes highly sophisticated, having in hands also a good potential to attempt to construct some acceptable physics on these phenomena in a subsequent phase.

In conclusion, practical experience (at least, mine) has shown that when we study phenomena of such a particular kind too sophisticated instruments may reveal to be totally useless. The sophistication must come only from the way in which we use instruments, which must be totally practical and portable. Spectroscopy is in itself a highly specialized operation, requiring the professionalism of an astronomer, of a physicist or of an optical engineer: this occurs in the phases of both data acquisition and data analysis. The final phase of physical interpretation is rendered possible only if the acquisition and analysis phase have been performed without even the shadow of a mistake or an uncertainty. In order to accomplish this task it is necessary, thanks to the acquired experience on the field, to fix once and for all the standard procedures to be adopted, which can be learnt doing some constant exercise (including ability of promptness on the field). Moreover, a strategic and tactical aptitude must be always joined to the techniques that are being effectively used.

Of course it would be very nice if such spectroscopic measurements could be carried out automatically using the same philosophy used when automatic video frames are acquired of these phenomena (such as using the Norwegian "Blue Box" and the Italian SOSO system). Unfortunately the implementation of an automatic spectrographic system of high quality and having all the prerequisites discussed before is quite a difficult operation that requires a lot of software work. On the other side, it is relatively feasible to apply a transmission grating to one of the video cameras or CCD cameras (used in this specific case in video mode, able to acquire, for instance, one frame per second), but if we want to obtain a sufficiently good spectral resolution we need to zoom (namely, increasing focal length) on the target. The problem is that the automated camera system doesn't know which target to zoom in. Automated video or CCD cameras are activated whenever a signal reaches and exceeds a certain threshold luminosity level (Project Hessdalen, website) but they do not distinguish the nature of the recorded light. This light can be recognized and identified only later by expert personnel. For instance the SOSO camera is currently able to identify several atmospheric sprites and meteors, but it cannot zoom on them at the time in which they appear, unless some (presumably complicated) "intelligent software" is used. The increase of focal length is a basic operation to furnish higher spectral resolution. Of course this can be accomplished if the camera has an acceptable spatial resolution too (a very refined luminosity gradation must be shared among pixels in the sense that every single pixel must be able to record a different reading without averaging over few pixels luminous signals that are spread over a large area). But such automated systems, so far, seem not to be able "to decide" what must be done time by time in order to optimize a procedure, which must bring to analytic science and not only to simple documentation (or unsophisticated science). This is the reason why so far only specialized personnel present on site is able to obtain scientifically decent spectra and not very low-resolution (and almost useless) spectra of all the luminous objects that are recorded in the view field every chosen time unit. This can be done only if spectra are taken directly on the field by specialists, whatever is the sacrifice that all this costs: experience shows that

all this, even if not so easy, is effectively feasible. Only human determination can bring to real scientific results, considering that here one doesn't want at all to drive his own research to prove an hypothesis of which he is in love but rather to obtain results that have a real scientific relevance whatever results may come out: our goal is to be able to describe objectively and understand the nature of reality that surrounds us. Otherwise, experience shows, once again, that monitoring operations are almost time lost, while claimed results are more often the illusion of a result. The ratio **efforts/results** must be increased, on the contrary this research is destined to stagnation and death.

5. VLF-ELF recordings

It is suspected that earthlights are able to produce an electromagnetic field both in the low (VLF-ELF: 10.000-10 Hz) and in the high (UHF: 0.8-10 GHz) radio ranges (Zou, 1995). In particular, the first range has been investigated mostly. Intermediate radio range (VHF: 30-300 MHz) has been investigated as well in 1984 by Project Hessdalen (Strand, 1984; Smirnov, 1994).

Let's now concentrate on VLF-ELF radio range and the results that have been obtained so far in the field of earthlights. Here the suspect is twofold: 1) earthlights are able to emit themselves very low-frequency emission (Zou, 1995) and/or 2) an area of Earth where VLF-ELF emission is the highest – due to geophysical causes such as pre-earthquake situations and/or piezoelectric-triboluminescence effects from rocks undergoing fracture or to similar causes – can be the main source of earthlights (Devereux, 1982; Teodorani, 2008a). In a few cases, such as Marfa, Texas (Odenwald, website; Teodorani, 2008a) some investigators have detected an increase of normal ionospheric emission just at the time in which earthlights appeared, but the true physical reason why all this happens is not known. The surest suspect so far is that locations that show a strong activity in the VLF-ELF range may have a quite high probability to produce earthlights. In fact it is confirmed that rocks under tectonic stress due to several geophysical causes (especially close to fault lines) produce normally this kind of EM emission, while the apparition of anomalous lights would be simply a consequence of such geophysical stresses (Derr, 1986; Devereux, 1982; Freund, 2003). If this is the main suggestion in order to attack the problem, the monitoring of the VLF-ELF range – and, in case, of the ULF range (0.01 – 1 Hz) too (Ghedi, 2003) – remains quite important in order to search for indirect markings of earthlights. In some other cases, especially in Hessdalen, it has been suggested that unexplained signals in the VLF range, might work according to a mechanism that is not related to geophysical activity (such as tectonic stresses or seismic precursors, for instance) but which seems more similar to ionospheric phenomena even if showing some very particular characteristics: scientific speculations on the possible origin of such anomalies directly from earthlights have been ventured (Teodorani, 2004a). Nevertheless at the present time no convincing synchronicity between earthlights and VLF-ELF anomalies has been recorded so far. Of course this might be due to the fact that earthlights are indeed present in the area but only when they are emitting in wavelength ranges that are invisible to the human eye due to their transient appearance as low-energy plasmas (Gori, 2002; Teodorani, 2004a). This clearly justifies the (hopefully) use in the near future of thermal imaging cameras in order to allow an appropriate monitor of the areas of interest.

Let's now pass to what has been done in this field. At the best of my information, VLF-ELF monitoring sessions have been carried a few years ago (IEA, website) in some states of USA (such as Arizona, Washington, and California), to one of which I collaborated as an expert of the optical range (Teodorani, 2005). Unfortunately, results of the analysis of such VLF-ELF data are not yet known. Similar monitoring sessions have been carried out in Marfa, Texas: in one of these an increase of the amplitude of the ionospheric emission has been recorded at the time of earthlights apparition. The Hessdalen area has been also massively and continuously monitored in the VLF-ELF range, using quite sophisticated receivers and very powerful antennas (Cremonini, 2003; Gori, 2002; Project Hessdalen, website): in such a case a lot of signals have been quite accurately recorded, most of which were ascertained to be of manmade and ionospheric origin or to be caused by instrumental intermodulation. By my opinion, a few of the recorded signals have not been really totally explained, if not “diagnostically dismissed” as apparently non-anomalous signals (Romero & Monari, 2005), in fact the doubt does remain. Some of these signals might remind some kind of ionospheric signal but other causes too might explain them (Teodorani, 2004a). Therefore the problem is still open.

In Hessdalen, a VLF-ELF system (called “ELFO”) has been stably installed close to the standard Blue Box, permitting to record automatically and continuously emissions in this wavelength range in the years 2006 and 2007 (Project Hessdalen, website). The problem is that – except for the careful analysis carried out on data specifically acquired in 2000 (Romero & Monari, 2005) – these signals have not been analyzed yet, while their synchronism with the possible apparition of earthlights occasionally recorded by the videocamera system couldn’t be checked due to substantial video camera inactivity in 2006 and 2007. Despite the very valid engineering (both Norwegian and Italian) solutions implemented in order to allow the non-stop registration of these signals (both from automatic video camera and the ELFO system), a physics-like diagnostic approach in this field has been seriously lacking in the last 5 years. Measurement instrumentation must be installed for a precise scope, which is physics investigation and not a sterile instrument implementation (whatever is the competent way with which engineering operations have been carried out). Physics investigation here has been and is presently inactive for several years. Of course I do not mean that this is a fault of someone. The problem seems to be mostly of money funding (including the one for myself to go on working in the Hessdalen area), which has been available only at some phases, but not continuously. Engineers, who worked in the area mostly, did a really good work in itself but then data acquired using the implemented instruments still need actions by physicists, who in general still seem not to be really interested in the Hessdalen phenomenon, at least in the operational sense. Except for a few short-lasting events (Gennaro & Gaiotti, 2004), physical scientists worked actively in the area only in the years 2000, 2001 and 2002 (Teodorani, 2004a). The lack of physics investigation in Hessdalen in the last years has been a very sad fact. After all, who should analyze and interpret the data furnished by the used instrumentation?

Apart from the many existing witnesses, experts of various sectors of science know that Hessdalen-like phenomena do exist, with much more conviction than 20 years ago. The way in which such light balls are able to remain self-contained and locally confined in a sort of hydrostatic/thermal/radiative equilibrium is one of the most interesting enigmas in physics today (Teodorani, 2004a; 2009c). This deserves a full physics investigation, hoping that more collaboration is realized with those scientists who are trying to reproduce similar plasma phenomena in a lab (Ohtsuki & Ofuruton, 1991; Teodorani, 2008a). Of course a phenomenon of this kind can be seriously investigated only if a multi-wavelength approach is promptly and efficiently put in practice, with the main scope to check how the phenomenon behaves when simultaneous multi-wavelength instruments are used. Many instruments have been used in Hessdalen, but such simultaneity, when realizable, has been checked very rarely.

Unless all of this has been an instructive exercise for students, in spite of the good engineering solutions that have been implemented, some practical and strategic mistakes have been done in the VLF-ELF field. For instance, the VLF-ELF “alarm data” that have been uploaded on the Hessdalen website in 2006 and 2007 are totally useless in the form in which they are now (Teodorani, 2008b). The X and Y scales with which they are presented are unreadable, uninterpretable and not comparable with standard scientific data readings. And, most of all, data in naive JPG format posted on a website are totally useless and senseless. VLF-ELF data that can be really quantitatively treatable for research must be rendered available to international researchers in WAV format (Radio Waves Below 22 KHz, website) so that they can be processed using proper scientific software such as *Spectrogram 16*, *Spectrum Lab*, *Spectran* and others. So it was not, at least in Hessdalen. Once more, I tell this not because I want to accuse engineers of something: they have no fault and they did and are doing anyway a good and precious work, which is irreplaceable both for physical scientists, who are intended to use such instruments with the scope of extracting data to make science, and for motivated students who want to learn science in a stimulating way (Strand, 2005). The problem, as it was said before, is probably due to the lack of a strategic and economic infrastructure that is supporting this kind of researches. Unfortunately, despite the professionalism and experience of physical scientists and engineers who have been doing this kind of investigations, the study of such anomalous phenomena is not sufficiently recognized as such by standard research institutes. Despite some technical workshops involving several scientists were carried out at present and (mostly) in the relatively recent past (ICPH, 2006; Project Hessdalen, website) Hessdalen-like phenomena are still considered a simple “curiosity” by most physical scientists who are not involved in this field. Mere non-operational curiosity is another source of time loss in this specific case. Experience has shown extremely clearly that a research that doesn’t possess yet the character of “mainstream” such as the Hessdalen one, is destined to stagnation and finally to death. If a specialized and duly recognized research institute of international importance will not be created in order to allow a systematic investigation of this kind of anomalies, the necessary discipline used to carry out a focussed research sooner or later will lack

and then vanish. Enthusiasm and “scientific curiosity” followed by no concrete action in the short-medium term brings to nothing, or almost.

Using (even sophisticated, as it happened indeed) measurement instruments just to show how they are able to capture light phenomena is only a part of the entire scientific story. Physical science should direct the entire stuff, but so it didn't happen, at least so far. In few words, at the present time, there is no political will to carry out this kind of researches at the level of the “Big Physics”. The logical reaction to this situation is that isolated but well-motivated and expert physical scientists attempt to carry out field-investigations alone, including, of course, the recording of the VLF-ELF ranges. These autarchic initiatives have produced something such as preparing and fixing, for instance, a quite rich standard database of known signals (Teodorani, 2008a) that constitutes the “noise” that must be carefully differentiated from the “signal” which is the main scope of this study. This happens also thanks to external experts who occasionally offer a quite precious advisory (Radio Waves Below 22 KHz, website; Seleri, 2005). In the case of my own work, I must confess that I devoted the last 5 years of my time (especially during summer holidays, but not only them) to a quite intense VLF-ELF monitoring activity, carried out in many places both in Italy and abroad (Teodorani, 2008a; 2009b; Teodorani & Nobili, 2004), of twofold importance: a) creation of a database of known and/or identified VLF-ELF signals of ionospheric, geophysical and manmade origin; b) selection of anomalous signals (some of which had a repeater indeed) whose origin must be investigated thoroughly (of course some of which might be identified in the future as prosaic signals). In general, if we exclude the quite well known ionospheric phenomena, my impression is that the VLF-ELF range has not been totally and extensively explored enough, and the occasion constituted by the effective existence of earthlights has been a quite important trigger to go deeper into this field.

Is a very powerful antenna so important to catch VLF-ELF signals? Of course yes, due to the inverse square law that governs the electromagnetic field (Lang, 1998; Teodorani, 2008c). Very weak VLF-ELF signals can be quite easily recorded only using powerful receivers, amplifiers and antennas. But this means two things: 1) weak signals may come from powerful sources that are very far from the observer; 2) weak signals may come from weak sources that are not far or even quite close to the observer. Now, considering that a typical light phenomenon of the earthlight kind can be appropriately recorded photographically or spectroscopically (or even using thermal imaging) only if it is relatively close to the observer (typically 0.1 – 10 km), the question is: Is it so useful, in order to study such phenomena, to use very powerful VLF-ELF systems that are able to catch *everything* that occurs in the range of hundreds or thousands of kilometres? The answer is a sharp no. And the reason is due to a lack of strategy. The strategy that should be used (and is partly adopted by someone) when one searches for a simultaneity between light phenomena and VLF-ELF emission, must be a focussed one, namely a strategy that is directly concentrated into the specific nature of the scientific problem that is investigated. In few words, I honestly think there is not much scientific logic in using powerful VLF-ELF systems (which, moreover, usually cannot give the possibility to furnish the distance of a given VLF-ELF signal) to record possible sources of this kind of electromagnetic emission when what we search is simply a source that is often located at relatively short distance from the observer. The use of a powerful system may increase largely the number of recorded signals, namely the ones whose source is at very large distance: we are not searching for these signals! And we are not monitoring the entire Earth, but simply a quite circumscribed area in order to search for VLF-ELF signals that are produced in case by the light phenomenon or that are indirectly correlated with it due to specific and local geophysical reasons. Of course someone might argue that if a light phenomenon that is relatively close to the observer emits weak signals only a powerful system is able to catch them: that's right. But none can exclude that such signals may be strong enough. We have now to choose among the less worse of the two problems and the discriminating factor is given by the cost of such instruments: a less powerful VLF-ELF system is much less expensive than a very powerful one, and, moreover, it is of a better strategic and tactical value due to the reasons explained above. Of course a VLF-ELF system (constituted by a receiver, an amplifier, an antenna) of small or medium (receiving) capability (Seleri, 2005) can be used both automatically all the time and manually. But the fact remains that a too powerful VLF-ELF system may be strongly inappropriate (and even confusing) and, in a way, not convenient at all. Quite recent past experience using a system of little-medium power very similar – if not slightly superior – to the ones used in Spring 2003 by Earthlight Alliance (IEA, website) has permitted to obtain a lot of data (regarding both identified and unidentified signals, some of which were particularly strong) in 5 years (Seleri, 2005; Teodorani, 2008a), whose signal-to-noise ratio was quite acceptable or even very good. In synthesis, my impression is that research that is specifically devoted to earthlights and the

electromagnetic field that is presumably correlated to them, does not need a powerful VLF-ELF system but rather a certain number of smaller and reasonably cheap and high-quality systems that, being fully portable, can be easily deployed to several critical areas of Earth where anomalous light balls are seen more often. A very portable and complete system constituted of a good magnetometer, a Geiger counter, a normal video camera, a digital reflex camera equipped with a good dispersion grating, and a computer-controlled VLF-ELF station, even if lacking of important instrumentation (such as an IR thermo camera and a microwave spectrometer), is able indeed to furnish sufficient scientific information concerning the specific phenomenon towards which our mental, tactical and strategic focus should be directed to. Results are very difficult to obtain in this field, but the know-how and the employed procedures have been repeatedly tested with success and satisfactory efficiency. The discriminating factor here is just the choice of the location where to concentrate monitoring operations. Most probable locations of recurrence of anomalous light phenomena in Italy are now quite well known (Teodorani, 2008a). The next step – strictly depending on sufficient money funding and the availability of specialized and competent supporting personnel – consists in organizing long-duration strategic monitoring sessions at night in areas whose criticality has been ascertained by previous scout short-duration operations. In Italy at least 8 areas of ascertained interest, also thanks to the informative collaboration of several qualified observers working in their own areas (45° G.R.U., CROSS Project; Progetto M.A.L.D.A.; Sassalbo Project, website; Straser, 2007), have been identified, in most cases, after explorative short-duration missions were carried out directly in those areas in the last 5 years.

Finally, the mode of presentation of charts concerning VLF-ELF recordings is quite important and must be standardized. Charts showing spectrograms or snapshots of them must show very clearly what their X and Y axis mean and, above all, their scale and numbers. It happens sometimes that these graphs are not specified in this sense, so that the external reader is not able to diagnose or compare quantitatively. Moreover the way to use the data acquisition software is important as well. Starting to acquire data directly using a 3-D representation (Intensity vs. Frequency vs. Time) is totally useless and might prevent the investigator to identify in real time the existence of a possible anomaly that is going on during registration. Therefore a 3-D presentation should be never used while VLF-ELF data are acquired. This way to show data may be necessary only in particular phases during data analysis and not during data acquisition. This approach has been chosen in the past by someone, and it should be avoided in the future. The most immediate way to check VLF-ELF data while they are under the acquisition phase is just to use a 2-D presentation (Frequency vs. Time), in order that possible signals of interest can be identified immediately on the screen: in such a way any decision to go on with registration can be taken. On the contrary, unless a signal is really very sharply distinguished, a 3-D presentation can often confuse who checks the data while the recording session is going on.

6. Microwave recordings

Apart from a relatively short-lasting monitoring session carried out in Hessdalen in summer 2000 when a 1420 MHz (of SETI-kind: *SS-5* and *Sentinel* units) spectrometer (Teodorani et al., 2000) was deployed for three weeks by Italian engineers and researchers of the National Research Council during their (/ours) first mission to the area, microwave detectors have never been used in earthlight research.

I am using normally a Natural EM Meter of the *Trifield* kind (+ magneto metric antenna) that has the ability to detect microwaves too. Unfortunately this measurement instrument (quite accurate in itself, anyway) is of analog type and doesn't allow any recording using a computer. This kind of instrument is quite useful as an "alarm system" (it includes a magnetometer system too): unfortunately readings cannot be recorded but rather only read out by eye. This is totally unpractical and renders this kind of instrument of scarce utility when real science is intended to be done. Portable microwave digital spectrometers should be used with the same frequency as VLF-ELF systems. In several cases (even if not explicitly in the case of earthlights) the suspect of a signature of "microwave beams" has been ventured, especially in the so called "crop circle" area, where strange light balls have been allegedly sometimes reported and theorized on the basis of the collected data (Haselhoff, 2001). The point here is anyway very controversial. Fringe ufologists and many "cereologists" already explained a-critically such occurrences as due to aliens, UFOs or typical new age issues, so that the entire crop circle issue has been almost totally discredited by the scientific establishment. Apart from suspiciously hoaxed films showing "light balls" vaulting over the crop before an alleged "pictogram" was created, the evidence of such light phenomena in those areas too cannot be easily dismissed (witnesses are

very many), while in some cases the crop seems to have been subject to some sort of heating effect that – in addition to many other much more prosaic and realistic causes – might be attributed also to microwave beams.

A microwave beam, in case of MASER kind (where microwaves are used in the same way as Lasers), is not an impossible manifestation, and it might be used as a “pencil” in order to create some of the crop circles, maybe as a “social experiment”. And the main point here is that its origin might be military (direct energy weapon systems are now a reality) and not necessarily alien. But the case of “crop circles” and other kinds of plain land art (whatever is the technique that may have been used) is only an example. In reality microwaves may be an important electromagnetic signature of a plasma manifestation of natural origin that might be the source of anomalous light phenomena: this is supported by several physical models concerning the formation of “plasma balls” such as the ones occurring recurrently in Hessdalen (Zou, 1995). We should also add the very realistic possibility that earthlights are not the source of microwaves but, conversely, that microwaves are the cause of them: this has been repeatedly proven in a laboratory (Ohtsuki & Ofuruton, 1991; Teodorani, 2008a). Maybe a mechanism of this kind might explain unexplained phenomena that are going on since 2003 in Canneto di Caronia in Sicily, where microwave MASER-like beams having a strong and focussed burning capability have been allegedly reported together with “light balls” in the same area (Teodorani, 2009c).

Therefore a microwave component should be stably added to all the other multi-wavelength detectors in order to try to cover efficiently a broad range of the electromagnetic field. Portable off-the-shelf instrumentation of medium sophistication of this specific kind is available in commerce. The present lack of its use in the specific research discussed here is quite a serious fact.

7. Radioactive particle recordings

Apart from the existence of possible very slightly radioactive remnants on the ground, which cannot be so far necessarily attributed to a direct approach by anomalous light phenomena (Teodorani, 2004a), measurement of alpha, beta and gamma particles might be an important procedure when such phenomena are investigated, especially if it is possible to ascertain with reasonable surety and accuracy that they have approached specific parts of the ground. Physical theories predict the deposition of gamma particles and of neutrons (Fryberger, 1997).

Nevertheless, the use of a Geiger detector in general seems to be of secondary relevance in comparison with all the other instruments, not because of its lesser importance in physical terms but because the probability to detect radioactive particles that are directly coming from a plasma ball is extremely low, especially if the light phenomenon is not very close (as it happens mostly) to the observer. A simple Geiger detector can be just added to all the rest of the instrumentation. I also have one of these instruments and have been using it many times also when light phenomena were in sight: in no case markings of radioactivity have been ever recorded.

8. Radar recordings

A radar device has been used with some success during the Norwegian monitoring campaign in 1984 in the Hessdalen valley (Strand, 1984). Past monitoring sessions have shown that such apparently plasma-like phenomena can produce sometimes a quite sharp radar track and that radar is therefore able to record the phenomenon’s position, direction, distance and velocity compared to the observer. This has probably happened also when the phenomenon was not in sight, possibly because it occasionally shifted to a longer wavelength than the optical: a similar phenomenology has been recorded by CNR Italian engineers too (Montebugnoli et al., 2002).

Nevertheless, a “transiently invisible” light phenomenon cannot be confirmed at all as such if radar registers a radar track somewhere. That track can be caused by everything. The only way to confirm its anomalous nature is just to scan the sky using a sophisticated infrared detector/recorder. The present lack of such an instrument renders radar tracks produced by an allegedly invisible plasma phenomenon, almost totally useless. Radar becomes really important only if a recordable infrared and/or optical counterpart can be confirmed as well. In

such a case distance, position and velocity of an anomalous plasma phenomenon can be obtained, so that very important physical information can be accurately obtained. For instance, the knowledge of distance matched with the measurement of apparent luminosity can furnish the absolute luminosity (Adams, 2007; Teodorani, 2004a), so that the energy density of the phenomenon can be accurately obtained. Therefore a radar instrument may become very important if its matching with simultaneous measurements carried out with other instruments can be guaranteed indeed. Radar has been installed some years ago in Hessdalen by CNR researchers (Montebugnoli et al.; 2002). Is that kind of radar the best choice in order to study a light phenomenon that occasionally may change position very fast? Maybe some other (more portable) kind – equipped with a rotating antenna – might be joined with this kind of radar, and possibly a maritime-type facility might be a sufficient solution also in terms of available range (typically 20 or 30 Km). The idea to install the antenna of such maritime radar on the roof of a SUV vehicle (with all the controls inside) is not so much a difficult task: this solution might permit researchers to move it at several locations very quickly.

Concerning distance determination of light phenomena a Laser Range Finder (a sort of very modern portable telemeter) might be a quite necessary additional tool, at least if its range can be at least of the order of 10 Km. The distance reading appears just on a sort of binoculars: when they are aimed at the target a Laser sensor measures and records its distance.

9. Magnetic recordings

Using a magnetometer may turn out to be a wise decision in several circumstances. This instrument has been often used in this kind of research, also in quite sophisticated form (Project Sassalbo, website; Rutledge, 1981; Strand, 1984; The Willard J. Vogel Study, website). Fluxgate magnetometer measurements carried out in 1984 by Project Hessdalen have been quite important to understand – or at least to describe in a more complete way – how luminous phenomena behave. This kind of measurement was carried out in Australia too (Strand, 1996). More recently, quite sophisticated portable digital magnetometers such as the *Meda* vector magnetometer has been used since 2003 during field missions (IEA, website), of which unfortunately, at the best of my updates, there is no publication yet showing the obtained results: reports describing such missions should be published even if no positive results have been obtained; the lack of results, in case, might be very scientifically instructive as well. Even if results are lacking it is sometimes important to publish brief technical reports showing the used methodology and procedures. This can be of great help for all other researchers in the field.

In some other cases good and meticulous magneto metric measurements using a less advanced instrument than the *Meda* magnetometer have been carried out and published (Akers, 2001). Unfortunately during those measurements the light phenomenon was not in sight. This is a very common problem when such measurements are carried out: sometimes some magnetic anomalies may be recorded but the investigation is kind of “blind” when one needs to know what exactly is producing a magnetic perturbation. The same happens with VLF-ELF (Teodorani, 2009b). Magnetic disturbances can be created by several causes that can be of geophysical, atmospheric and solar nature. Of course it is of fundamental importance to distinguish what caused those disturbances and the only way to do it is to always match magneto metric measurements with measurements done using simultaneously other instruments such as VLF-ELF, radar, infrared, and, of course, optical equipment. This occurred but not often enough, not because of negligence of researchers but due to several reasons such as the difficulty of carrying out such measurements in this specific circumstance, the elusive nature of the investigated phenomenon, the missing additional instrumentation due to the lack of money funding or instrument availability, the lack of a computer interface facility where to attach instruments (for instance the magnetometer that I am presently using, even if it is quite sensitive together with its antenna, is of analog type: there is no way to connect it to a computer), the lack of supporting personnel and other causes.

In general, an important concept should be clearly fixed here: if a magneto metric measurement is carried out – even obtaining important readings – if this instrument is not accompanied by measurements taken using other instruments, it may turn out to be totally useless. Magnetometry is a sort of “blind measurement procedure” if used alone. What causes magnetic disturbances should be promptly identified, if the circumstances are lucky enough. For instance, we are in a condition to dismiss magnetic disturbances as

“noise” if we are effectively able to ascertain that at the time of disturbances (or a bit before or later) a geomagnetic storm of solar origin is going on, if we are very close to ferromagnetic rocks, if we are inside an area of well-known geophysical magnetic anomaly, or even if we are close to some powerful manmade electric apparatus, and probably if other causes too contribute in producing such anomalies. If we are not able to identify such causes we can tell nothing regarding something that might be attributed to anomalous light phenomena, unless the time of their apparition coincides with the time of magnetic disturbances. Results of this kind have been obtained but very rarely: Project Hessdalen researchers were quite successful in these both in Norway and in Australia (Strand, 1984; 1996). Conclusively, it is this kind of result that renders magneto metric measurements of real scientific relevance in this research. On the contrary, even if anomalous magnetic signals are obtained but no light phenomenon is in sight, we just do a “blind measurement” of scarce utility. Maybe this kind of blind measurements can be anyway important to identify ascertained geophysical areas where magnetic disturbances occur very often: this may help in some way in our research as magnetic disturbances and anomalous light phenomena may be correlated in two ways: a) they can be emitted directly by plasma balls; b) plasma balls tend to occur at locations where geophysical anomalies (also of transient kind) occur very often.

Certainly a true result of strong scientific relevance is given by an ideal situation in which a light phenomenon is documented using video, photography, spectroscopy or even IR thermal imaging, while at the same time magnetic disturbances are accurately recorded. Only a situation of this kind can make magneto metric measurements of real scientific relevance in order to permit the construction of some physics. Otherwise research is quite sterile and often scientifically useless. A similar situation is true for VLF-ELF measurements too, even if VLF-ELF measurements usually furnish much more detailed information than magneto metric ones do.

And now a final consideration on this specific topic. Let's assume that we are able to achieve the result mentioned above. Are we sure that we have all that which is necessary to construct some solid science? The answer is no. Magnetic disturbances are just what we record at the position of the observer. In reality the source of them must follow some power law, according to which magnetic intensity decreases exponentially with distance. But if we do not know the distance of the source our physics dreams remain unsatisfied. In fact we need to know the intrinsic magnetic field intensity at the location where it is emitted from. That's the reason why a knowledge of light phenomenon's distance is absolutely necessary (using a radar, Laser range finder, or triangulation).

But here, if we are lucky enough, we might be put in a condition to use a “trick” that might solve several physics problems in only one hit: that is determined by optical spectroscopy. How can this be achieved? If we use optical spectroscopy of sufficient resolution we can be in a condition to record the Zeeman Effect in spectral lines (Lang, 1998; Teodorani & Strand, 1998). This typical symmetrical line-splitting effect is caused by a magnetic field whose source is exactly inside the plasma ball whose luminosity hits our eyes and our photonic instruments. Measurement of such line splitting can furnish to us the magnetic field intensity of the plasma ball exactly at the source. This is a really important chance that all physical researchers of such phenomena should aim at and this shows once more how optical spectroscopy may become extremely important if the light phenomenon is able to produce a magnetic field and if (of course) it produces a line spectrum (in the absence of which any effort in this sense becomes totally useless, unless one uses a photo polarimeter). If then, a digital magnetometer is used simultaneously with spectroscopy it becomes possible then to record both the intrinsic magnetic field intensity at the position of the source that is producing it and the magnetic disturbance (which might be called “apparent magnetic field intensity”) that is received by the observer. If we have at least two synchronous magnetometer readings at different distances from the source (namely, using two magnetometers), a simultaneous knowledge of distance (obtained using radar, Laser range finder or triangulation) allows researchers to derive the exponent of the power law according to which the magnetic field intensity produced by the source decreases with distance. If this law is then empirically known as a standard evidence for these phenomena, it becomes possible, conversely, to determine phenomenon's distance by doing simultaneous optical spectroscopic (with the intent to measure the Zeeman Effect in spectral lines, if present) and magneto metric measurements. This trick is quite similar, in the procedural sense, to strategies used in astrophysics when one wants to obtain indirect measurement of whatever physical and dynamical/kinematic parameters (Lang, 1998), such as distance for instance. Even if such an attempt is not so easy to realize, this philosophy of approach to the physical problem under study should be applied more often.

In practice this procedure has been never followed in earthlight research, not even imagined as a declaration of intents. This is only partly due to negligence (including the one by this author, of course), but rather to the elusive and unpredictable nature of the light phenomenon and to the lack of redundant supporting personnel when a certain measurement procedure is carried out, which most often acquires the character of “emergency”. That’s the reason why promptness and solid organization should be established before carrying out monitoring sessions on the field. Such a wiser approach to observational/experimental research on anomalous light phenomena can be improved with several exercises using a similar methodology as in the military, for instance. It must once and for all reminded, in fact, that monitoring sessions on light phenomena, in order to produce real results, must be carried out with a full and experiential knowledge of the reaction times that are needed. And finally, it must be also reminded that experience has showed very clearly that whenever a measurement session using simultaneously several instruments is carried out, only one researcher may not be sufficient to manage all the used equipment. This happens also when, except for the camera (+ spectroscopic grating) whose managing is entirely manual, the other instruments, being computer controlled, are recording data automatically. In reality these operations need tactics, strategies and quick decisions, which can be taken only if someone is constantly checking what is being displayed on the computer screen. For instance, if the VLF-ELF system records transiently apparently unexplained signals, if the magnetometer records an unidentified magnetic disturbance or if the radar is receiving a transient track, being at the same time no luminous phenomenon in sight, this means that time has come to activate the thermal imaging camera in wide angle mode in order to scan the sky until something is identified and potentially subject to subsequent zoom actions in order to acquire details on the “invisible” source. If all these actions are not done, no data of real physical relevance can be obtained. This brings inevitably to research stagnation, demotivation and loss of interest.

From all of these considerations it is easy to deduce that instrumental research on anomalous light phenomena is quite complex and very difficult to carry out, if strategies, tactics and a sort of “institutional infrastructure” are lacking. That is one more reason why a few months ago I accepted to be a scientific consultant of a politician who is presently presenting an interrogation to the European Parliament in order to promote the creation of a truly structured scientific Centre (Teodorani, 2009d) devoted to the study of anomalous aerial phenomena, which include all the known variants of the problem under the more or less known acronyms of “UFO” (Unidentified Flying Objects), “UAP” (Unidentified Aerial Phenomena), “EL” (Earthlights), “EQL” (Earthquake Lights), “BL” (Ball Lightning).

10. Electric and electrostatic recordings

Some physical theories predict that anomalous light phenomena may determine the deposition of electrostatic particles (Fryberger, 1997) or the creation of an electric field. A detector of such kind has never been used in this specific research, except for, at the best of my knowledge, only once, when an interesting testing exercise was carried out by some ICPH researchers during not-easy atmospheric conditions (Gennaro & Giajotti, 2004; ICPH, 2004). As it has been said previously concerning the strategy adopted using other measurements instruments, a measurement carried out using an electrostatic detector or an electric field detector acquires a sense only if anomalous plasma phenomena are under recording using optical and/or infrared facilities (in case supported by magnetometry, VLF-ELF and other electromagnetic instrumentation). If no evidence of aerial plasma phenomena exists, the use of an electrostatic detector may be almost totally useless, unless it is used to measure some aspects of atmospheric electricity which might be added to other environmental measurements carried out using a complete atmospheric station: the measurement of atmospheric parameters (including electricity) in general may be anyway important in order to establish the “contour” inside which anomalous light phenomena tend in general to occur, in such a way that electrical/electrostatic measurements of environmental emission might permit to establish a local connection between light phenomena and atmospheric electricity. Moreover, it should be determined if the possible recording of electrostatic particles or of an electric field is really caused by atmospheric electricity or to geophysical effects such as piezoelectricity due to tectonic stresses. The ascertainment of “what is what” can be done only if other instruments are used and/or geological/geophysical surveys are carried out at the same time of electrical measurements or around it.

Very portable instruments such as a Natural EM Meter able to measure also the electric field, such as the *Trifield* one (in most of its variants), is a bit useless. It is able to record electric fields only at a short range and

it is not able to accept a computer interface for data recording. Of course specialized high-level instrumentation (Gennaro & Giaiotti, 2004) is highly invoked in more future missions.

Clearly, an electrostatic/electric field instrument too (which might turn out to be very important in the physical way), must be most often intended to be used having a focussed goal in mind that can be synthesized in this evergreen question: Is there a direct correlation between the physical evidence of earthlights and the emission of electrostatic particles and/or electric fields?

11. Triangulations and stereography

Triangulation may be a quite effective methodology to derive the distance of a given light phenomenon that is occasionally sighted by two or more observers that are located at different positions. The wider is the used baseline the more accurate can be distance determination using quite simple trigonometry. An attempt of this kind has been done in the past by project Hessdalen through its Blue Box automatic station adopting the wise strategy of using two video camera systems (Project Hessdalen, website) located at some hundreds of meters apart, but at the best of my knowledge, I didn't see published results yet in this sense or even if this kind of triangulation opportunity was used or not. An interesting and quite precise triangulation result has been obtained by International Earthlight Alliance researchers in Hessdalen, summer 2002 (Adams, 2007).

In any fact, once other kinematical parameters (such as light phenomenon velocity, for instance) are used (this may not be strictly necessary, but in general it empowers a given investigation), triangulation operations may turn out to be extremely important whenever radar and/or Laser range finder detections are lacking. Of course in order to accomplish this it is necessary that at least 2-3 observers are available to monitor the same light phenomenon, looking at the same direction, in case supported by good compasses and (much better) data scopes.

A "mini-triangulation" operation might be also carried out using two cameras of the same type that are separated by a distance of some meters. Then a common trigger must activate the shutter of both cameras simultaneously. This procedure – called "stereoscopic photography" – has been used very rarely in earthlights research (Sassalbo Project, website). Despite the very small baseline constituted by the distance separating the two cameras, stereoscopy should be attempted more often.

12. Laser tests

As it is very well known, an experiment carried out in 1984 by Project Hessdalen researchers in the Hessdalen valley demonstrated that the light phenomenon seems to "respond" to the stimulation of a Laser beam (Strand, 1984). At the time a 0.76 mW Laser was used. At present much more powerful and portable Lasers are available. Of course many ufologists of the "I need to believe – fringe" attributed the "answer" of the light phenomenon to Laser stimulation, to an intelligent action by aliens of some kind. In reality still we do not know yet many aspects shown by light phenomena, including physical mechanisms of photon-photon interaction. The reaction recorded by Project Hessdalen researchers was real but not necessarily "intelligent", even if this cannot be a-priori excluded (Teodorani, 2006). But this is an extremely delicate subject that must be treated with maximum caution. Anyway, a possible interaction between observers and anomalous light phenomena is quite well documented everywhere in the world: this did not only happen as a reaction to Laser stimulation, but also in other forms (Teodorani, 2008a). Apart from the childish (but innocent) fantasies of who "needs to believe" (Teodorani, 2009a), the problem of interaction between humans (and/or animals) and this kind of phenomena must be investigated thoroughly, having also well in mind the quite recent discovery that plasmas in particular conditions do behave like the (biologic) DNA (Tsytoovich et al., 2007). This may not be a chance, so that the existence of "plasma life forms" in the interstellar space and in our atmosphere cannot be, at the present time of our physics knowledge, dismissed as pure science fiction. It follows quite directly that if a plasma ball is a sort of life form, such life form is expected to react – not necessarily, intelligently – to any kind of stimulation, including a Laser beam. That's the reason why the Laser experiment that has been carried out in Hessdalen by Norwegians in winter 1984, must be attempted many other times both there and

elsewhere. It seems that similar reactions have been reported in 2009 in the Northern Apennines in Italy (Progetto M.A.L.D.A., website), but this is a bit more than a witness (not differently from the one furnished by Norwegians).

In reality a “Laser reaction” must be very carefully and accurately documented using a video camera that is working simultaneously with the Laser, while all that which is recorded must be quantitatively analyzed. The best way to do this is to put both the Laser and the video camera on the same tripod by using a specifically employed “arm” that is mountable on the same tripod. A very similar configuration has been tested in summer 2009 by Project Orbwatch (website) in Ontario, Canada. I was collaborating with such a mission (Teodorani, 2009b). The used Laser was of very high power, being 275 mW, and its range exceeds 100 Km. This is just what I myself recommended before it was bought by Project Orbwatch. Unfortunately such a very powerful instrument (which is ideal indeed to reproduce the Hessdalen experiment in a much amplified form), which we tested successfully before being actively engaged in our explorative missions in the area, could not be used on the field. The reason is very simple. At those locations there was a permanent risk that inadvertently an airplane was hit by the beam. This can be dangerous even from large distances and it is, of course, forbidden by law. A radio scanner was constantly used during airplane passages but the caution that we decided to use at those specific locations (very crowded with airplane passage) was such that, except for one opportunity (when unfortunately our reaction times were too slow in order to activate the Laser), we (frustratingly) never used this instrument. This experience has taught us very clearly that a (very powerful) device as such cannot be used in any way when and where the airplane traffic is normally intense. Experience has taught me that more suitable locations for this kind of operations to be carried out successfully are only in reasonably desert areas (where, also, air traffic is very little). I might mention here three examples of such suitable locations, coming from my own experience on the field: the Arizona desert, where anomalous light phenomena are reported with some recurrence (Teodorani, 2005), some areas of the Italian Northern Apennines, such as Solignano, Montefiorino, and Pietra di Bismantova, and one quite interesting area of the Italian Central Apennines such as some (but not all) around Monti Sibillini and Piana di Castelluccio (Teodorani, 2008a). In all of these cases anomalous lights have been reported (and partly photographed) during field missions (see Fig. 2). Of course the Hessdalen area has not been forgot in order to carry out new, more sophisticated experiments, using a powerful Laser such as the one that was tested in Canada.

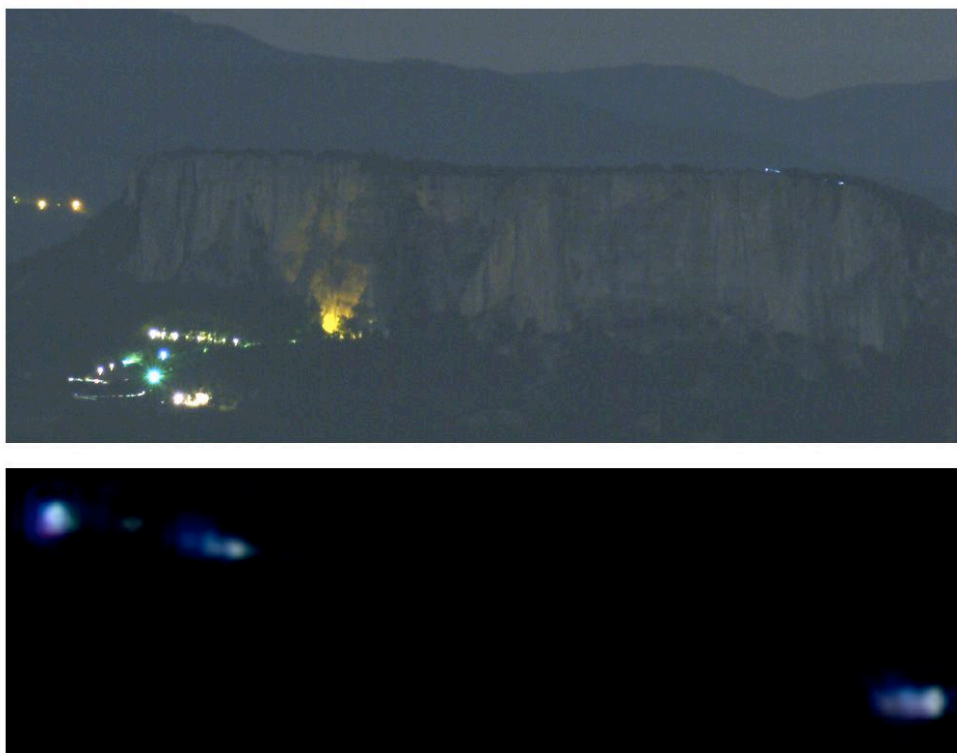


Figure 2. Suspect transient fast moving earthlight photographed by this author using a *Fujifinepix S-2 Pro* reflex digital camera equipped with a 70-300 mm lens. Location of anomaly is on the top of a flat mountain called Pietra di Bismantova (RE), Italian Northern Apennine area, on the right side. Enhancement is shown below. The date is July, 8, 2009, at about 23:00 local time. Photo was taken from a spot located a few Km away from Montefiorino (Mo).

Conclusively, assuming that the appropriate area is chosen, what are we going to do with a Laser assuming that it is aimed at a light phenomenon that is transiently appearing? The tripod/instrument configuration should be exactly the same as the one prepared in summer 2009 in Canada. Of course in this specific case we need to check what happens mainly in two ways: 1) to the light ball itself: is it reacting turning off, increasing luminous intensity or changing colour?; 2) to the Laser beam itself: is it altered in some way, such as curving, for instance? (Teodorani, 2000; Teodorani & Strand, 1998). Very sophisticated research programs have been accurately planned in order to test a possible connection between the Laser stimulation to a “light ball” and human brain activity reaction (Teodorani & Nobili, 2007). All of these planned tests, if the correct situation of use can be safely configured, might furnish very important physics information (even the most exotic, in case) and must be attempted repeatedly, once the most appropriate location (a good compromise between frequency of phenomenon recurrence and the desert character of these areas) is definitely chosen and settled.

The experiment carried out by Project Hessdalen, though not explaining the nature and the physical reasons of the reported reaction to Laser light, was quite wise and well done. This experiment must be repeated more and more times, whenever the local conditions render this possible. 25 years later available Lasers have greatly increased both their portability and their power. So, let’s find out a way to repeat the experiment again in Hessdalen and elsewhere.

13. EEG recordings

The use of a portable (computer-controlled) electroencephalograph is quite a rarity among the instruments used in earthlight research. The intent is to try to verify if the electromagnetic field that is possibly associated with anomalous light phenomena is able to affect brainwave activity. EEG techniques have been used in the past in crop circle research (Pringle, website), but I didn’t find yet publications testifying the use of this technique in earthlight research.

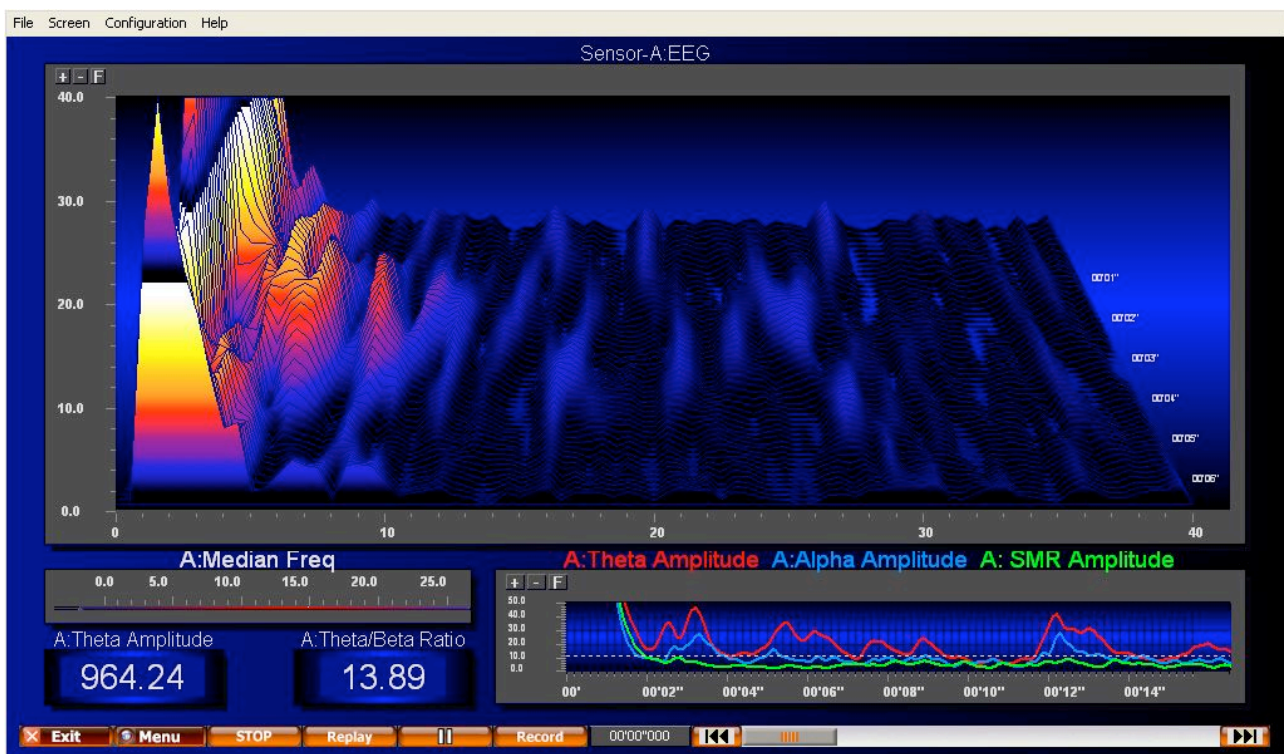


Figure 3. An example of EEG of a “test person” acquired by Dr. Gloria Nobili and post-processed further by this author. Such an EEG experiment was carried out at an area where anomalous light phenomena are recurrent. The *EEG-Trainer* (Dual Channel Neurofeedback Trainer: <http://www.mindmedia.nl/english/eegrainer.php>) was the instrument that has been used in order to obtain such measurements.

Considering the possibility of an interaction between anomalous light phenomena and human physiology – in particular human neurophysiology – since a few years my group is occasionally using an electroencephalograph through the person of Dr. Gloria Nobili, a physicist with a particular interest for biophysics. The idea is to check if during the apparition of anomalous light phenomena (in areas where they are reasonably recurrent), or simply at specific locations where such phenomena are often seen, some alteration occurs in the (alpha, beta, theta) brainwave. The same technique has been also tested to some alleged “experiencers” and/or “contactee” (none of which, by the way, demonstrated their “visionary capabilities”), and normal persons. Obtained results showed in time how the use of this technique, though being quite sophisticated, requires a lot of redundant measurements to be considered reliable. In order to do this it is necessary that some “physiologic standard zero point” is always maintained: for instance, closed eyes, open eyes, fast breath, slow breath, etc. One of these setups must be chosen as a standard, but it is not always easy to make so that the tested person really respects this rule. For instance, conditions of closed or open eyes produce two different tracks in the brainwave, therefore a standard must be absolutely chosen, fixed and maintained in order to have a standard reference or zero point when whatever scientific check of a possible interaction of light phenomena with brainwave is carried out.

Out of several attempts done at different locations in Italy EEG measurements carried out in the field were never accompanied by an anomalous light phenomenon in sight (phenomena sometimes were seen when the EEG was not in function), even if the areas where such measurements were done are indeed characterized by a high frequency of light phenomena. In some cases strong “Theta states” readings and recordings have been obtained (see Fig. 3): this is very typical of meditation states or, anyway, of a “particular state” of the brain. Nevertheless a single measurement is not absolutely sufficient to demonstrate that certain locations really affect the brain of people: in fact altered states such as the Theta ones can occur during many circumstances of normal life. Many more measurements must be carried out for a long time, and not only on a single person but also on many other persons. This particular aspect of research requires a very long time and dedication and not only a few tests. Nevertheless the tests that were carried out turned out to be sufficiently instructive to teach us what we really need in order to make a truly scientific investigation on this aspect. In fact we verified that the enterprise is not impossible, but also that (especially without money funding, without enough time available and the support of additional personnel) it is anyway very difficult to do it in a way that a full scientific approach is guaranteed. The action of carrying out this kind of measurement while an anomalous light phenomenon appears has, objectively, a quite low (but non-zero) probability of success. Experience on the field showed that the use of five independent electrodes (such as the ones that are typically used by the *EEG Trainer*), though giving a quite high accuracy of brain measurement, may be very unpractical at night in the field. Other kinds of EEG instruments, where all electrodes are “compacted” into a single “forehead belt” with no wires to the EEG and the computer controlling it but rather using a wireless system, are much more practical (even if less accurate) and may allow this operation to be done at several conditions, if the standard physiological setups are maintained rigorously. This kind of measurement, being quite well realizable in normal control conditions (as it has been effectively done in many occasions by Dr. Nobili), is extremely delicate and hardly controllable at the specific situations described above. This specific research, to be carried out with the necessary rigour, is not an impossible task but it requests for more helping personnel once each of the standard zero points are accurately fixed and maintained. If an EEG with independent electrodes is a more accurate system (ideal for actions done not in the field but in normal environments), an EEG type using the forehead belt – such as the Interactive Brainwave Visual Analyser (IBVA) - is much more practical for specific operations as the ones described above. In conclusion, this kind of measurement, even if very important in itself – including very sophisticated experiments that have been accurately planned (Teodorani & Nobili, 2007), but not yet carried out – needs a very accurate preparation and more than one expert to collaborate: of course in this case too, money funding and a very specific scientific infrastructure is absolutely necessary for this kind of research.

Conclusive remarks

All of these discussions, concerning the use of several measurement instruments in earthlight research, have shown that if one really wants to carry out rigorous research a lot of difficulties must be solved, many of which are practical difficulties caused by the elusive nature of the investigated phenomenon itself and by all the problems that are necessarily encountered by everyone who is involved in this research. One thing must be

clearly fixed: this research, to be conducted rigorously, is probably much more laborious than any other physical research. Being the funding to this research so far extremely limited and sometimes totally absent so that only a few enthusiast researchers often self-fund their monitoring operations, many other researchers do not find the motivation to be involved. This is the reason why institutional organizations and/or wealthy structured private organizations should take the control of this research, so that it can be managed much more efficiently. But “standard physical scientists”, still now, though some of them are quite intrigued by the phenomenon that is under study by us (“non-standard physical scientists”), are in general distrustful: this is caused by several reasons, such as ignorance, fear of the unknown, and also the fear to be ridiculed by the gossip of uninformed colleagues. This research, although being effectively scientific compared to that which is done in standard ufology, may be discredited sometimes by the so called “new agers”, who, without understanding anything about them, often take some results obtained by serious earthlight researchers to exploit them according to their uncritical faiths and convenience. Medium-term experience shows that it is not at all advisable to give talks in public on these specific subjects or to write divulging papers addressed to people who are scientifically uncultured or lacking in the necessary critical thinking. Not being at all prepared in scientific methodology and not being used to an objective evaluation of problems, which is typical of the inter-subjective structure that is science, a large part of the general public tends to pick up only what hits their emotion by ignoring totally the dialectics and methodology that is behind a certain research. Common people want absolute truths at once and not scientific reasoning. This is a good reason to state that this research should be communicated and published (and orally presented) only in technical form or, at least, in a form that can be readable and correctly interpretable only by experts. I have acknowledged quite well my own previous excess of faith in the capability of normal people to understand something scientifically on these specific issues, by learning on my own mistakes. In conclusion: the public and the media must be absolutely avoided when certain subjects are discussed.

Another problem that afflicted this research has been a wrong way to object to obtained results, especially among people who do not know each other sufficiently well. This is quite well and impartially documented by an IEA researcher (Adams, 2007). This has brought to an incorrect and totally unproductive criticism, which is not healthy to research. But this has always been happening in the history of science when “fringe subjects” were studied thoroughly by a few motivated researchers. Several quite close-minded researchers seem still to ignore that some form of “open mind” comes from rational persons who want to make science advance. Of course all this costs a lot, but it is the only possible step towards innovation. In reality, apart from all the problems that have been widely discussed here, earthlight research has produced some results, and today we know much more than 10 years ago, both in terms of the physical behaviour of the light phenomenon itself and in terms of all the problems that can be now very well fixed and understood in order to produce concrete improvements. This research is not for people who think in the same way concerning the nature of the phenomenon, or for researchers who are in love with their own theory, but rather for researchers who share different ideas and procedures under the common light represented by rationality and authentic scientific methodology. This research, just due to its peculiar nature, requires a higher rigour than other more prosaic researches in fundamental physics. Of course a sceptical approach is highly desired and encouraged.

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