Physics from UFO Data

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Abstract

A research project on the UFO phenomenon is proposed in which UFO targets are treated on a par with astronomical objects having no fixed coordinates. Specifically oriented monitoring techniques and strategies involving small telescopes which are connected to CCD (charge coupled devices) detectors, spectrographs and photon-counting photometers are presented. Expected exposure-times for acquiring a good S/N (signal to noise) ratio of the target using all the proposed instruments is also evaluated. Finally, physical informations which are expected to come out from data analysis are presented and discussed in detail.

Foreword

Not all UFO sightings which have been reported in the world are characterized by short duration or appear accidentally in various areas. There are some particular cases in which such phenomena seem to be restricted to very specific zones (Appendix). The Hessdalen phenomenon, for which previous measurement campaigns have been carried out (ref. 12, 16, Appendix), is a clear example of this distinctive feature and for such a reason it can be considered the prototype of the so called “recurrent UFOs”; moreover, its great luminosity and duration (ref. 12) can allow scientists to track it quite easily with suitable instrumentation. This particular UFO behaviour, which at present has been reported in at least other 15 areas of the world, offers physical scientists the opportunity of acquiring quantitative data by using instrumental stations which are supplied with multi-wavelenth and multi-mode sensors. The work presented here is intended to be a research proposal whose main goal is of obtaining a complete set of physical parameters which are necessary in order to permit the construction of well-founded theories. An accurate and complete choice of specific instruments is the best way to accomplish such a task: in order to do this, and because of the pragmatic scope of this work, it is important to furnish precise scientific and technical details. This paper is subdivided in two sections: the first one dedicated to instrumentation for data acquisition and the second one to the physical parameters which can be subsequently obtained.

The first section describes a multi-sensor platform constituted of a set of photometric and spectroscopic instruments, while the second section describes the way in which such physical data are expected to be analyzed and interpreted. Photometry is aimed at measuring both the light intensity of a given illuminated target and the way in which light photons are distributed over the light-emitting area. Spectroscopy is aimed at studying both the physical emission mechanism of the luminous phenomenon itself (from the continuum spectrum) and the excitation level of the atoms which are producing the light (from the line spectrum).

As light is emitted from very specific wavelength-windows and the used sensors can’t allow measurements of all the windows at the same time but need specific filters for each of these, it is necessary to perform photometric and spectroscopic measurements per each window: this is essential in order to obtain a simultaneous picture of a probable multi-wavelength light phenomenon. An instrumental monitor which is simultaneous in several wavelength-windows is very important because the UFO phenomenon is expected to be highly time-variable, also on very short time-scales: therefore it is indispensable to synchronize the data which are expected to come from multi-wavelength observations. For instance, this procedure is essential in order to permit a technical treatment of the physical parameter related to the UFO color (color index), which in the case of highly variable phenomena such as UFOs can be obtained only after acquiring simultaneous data in different wavelength-windows by using proper filters and later after calculating ratioes of the luminosity values in two contiguous windows. In principle a very similar research philosophy is commonly applied in astrophysics in order to study multi-wavelength celestial sources such as pulsating stars (ref. 6). Only by using such approach it can be possible to establish time-correlations between the light behaviours in different wavelength-windows: this is the main reason why for every given wavelength-window the use of multiple detectors (such as CCD detectors) and multiple analyzers (such as spectrographs) is highly required.

Particular photometric data, such as the ones coming from “photon-counting” photometry, are also requested in order to check a possible very fast variability of the light phenomenon which cannot be detected at all by the low time-resolution of camera-like or eye-like light detectors. Spectroscopy is intended to be executed in two modes: low resolution and high resolution. Low resolution is aimed at obtaining a preliminary spectrum of a given target: by using this procedure it is not possible to obtain morphologic details of spectral lines (if present) but it is possible to deduce quite well the emission mechanism (thermal or non-thermal) and the temperature (for thermal mechanism) of the light phenomenon just by studying the shape and the slope of the spectrum displayed on the overall investigated wavelength range (optical, for instance), which is itself constituted of more wavelength-windows. High (or also medium) resolution is aimed at measuring precise details of the spectral lines (if present): this procedure can be of basic importance in order to obtain important physical parameters such as density, pressure, chemical composition, intrinsic magnetic field, object rotation and gas ejection effects.

It will be shown later that it is much more problematic to acquire spectroscopic data than photometric ones, as the quantity of recorded photons obtained by using spectroscopic techniques is much lower than the one obtained by using photometric techniques: this means that the exposure times, which must be used in order to record light photons emitted from a given UFO target, are much longer in the spectroscopic case (high-resolution spectroscopy being the extreme case) with the consequent effect that only very luminous, very close and/or long-lasting UFO phenomena can be studied with this technique. All these specific characteristics are very often encountered in the Hessdalen-like phenomena, in particular (ref. 12), but sometimes also in some nocturnal lights of the “structured” type (ref. 13) which, even if short-lasting, may show a very high luminosity: therefore high-resolution mode for spectroscopy is strongly encouraged in these cases expecially because of the results of great relevance for the physics which could be obtained.

It is also shown that photometric and spectroscopic instruments must be necessarily connected to telephoto lenses with wide-angle capability and/or to mini-telescopes of the reflection-type, in order to allow the proper collection of the photons which are expected to be detected by photometers and analyzed by spectrographs, and to amplify (mini-telescopes), in case, the light of distant or small luminous targets. The instrumental redundance which is recommended for photometric and spectroscopic light-measurement devices is expected to be coherently applied to the light-collectors devices too.

Furthermore the importance of acquiring in time-sequence many photometric and spectroscopic frames of the same tracked UFO target, is strongly emphasized: temporal variability of a given luminous target, such as pulsations or changements of pulsation rate of the type recorded in Hessdalen and elsewhere (refs. 11, 12, 13, Appendix), can furnish, from a dynamical point of view, precious insights on the physical mechanism of the UFO phenomenon in general.

Finally, the indispensability of using a radar and/or additional devices in order to search, point and track UFOs, is also emphasized; the UFO phenomenon is typically characterized by a random motion but its radar signature is often strong (refs. 12, 13): in such a way a luminous phenomenon of both metal-like and plasma-like nature can be quite easily alerted by a radar apparatus, and measurements can be consequently carried out by assuming that photometric and spectroscopic devices are attached directly to the radar device. Moreover the radar device is indispensable in order to furnish the target’s distance, so that it is possible to obtain both the intrinsic dimensions and the intrinsic physical parameters of the target.

The physics discussed in the second section of this paper, is directly derived from the basic “photonic physics” which is commonly used in the astrophysical research (refs. 5, 6): it will be technically demonstrated that this matter can be highly suitable also for measurements of UFO phenomena on condition that some adaptation is done for these specific physical objects. The discussion in this section is devoted primarily to classical physics subjects and secondarily to relativistic subjects. Relativistic treatment seems to be invoked in order to try to explain some strange reported evidences regarding “curved lights” which occurred in concomitance with UFO incidents (ref. 13).

1. Introduction

Previous instrumental projects on the UFO phenomenon, as "Project Hessdalen" (12) and "Project Identification" (ref. 11) and their results, demonstrate that it is possible to face this problem with the same galilean rigour and method by means of which more canonical physical problems are treated. In particular, “Project Hessdalen” is going on at the present time (1999) thanks to automated instrumentation (the *Hessdalen Interactive Observatory*) based on sophisticated videocameras, radio spectrum analyzers and magnetometers, which are able to alert the passage of UFO phenomena (ref. 12). The instrumental monitoring program proposed in this work (ref. 14, 15, 16, 17) is intended to be a scientific support to the previous and current applied projects and an occasion of discussion for future improvements of UFO research. Such a program involves the use of instrumentation which is commonly used in the astrophysical research in order to collect, detect and analyze photons which are emitted by celestial objects. As UFO targets have typically no fixed coordinates and are often subject to random or unpredictable motion, it is necessary to guide the whole measurement platform by means of a proper device. For this reason it is proposed to connect astronomy-like instrumentation to tracking devices of military type, such as a radar and/or a laser telemeter (ref. 18). By using such a strategy it is possible to obtain very accurate data, which, once analyzed, can furnish fundamental informations on the physical mechanism which governs the UFO behaviour. If such a procedure can be applied, the whole UFO phenomenology, so far mostly circumscribed to the evaluation of simple witnesses (ref. 13), could be treated with the same physical methodology with which an astronomer studies celestial objects. In general, it is very difficult to predict where and when the UFO phenomenon is going to occur. Nevertheless, the existence of some regions of the world in which the phenomenon happens most often (refs. 11, 12, Appendix) offers the most favourable conditions in order to apply monitoring techniques.

2. Instrumentation and observational strategies

The proposed idea consists in using astronomical light detectors and analyzers which are connected with easily transportable small large-view-field telescopes or telephoto lenses, in order to acquire images and spectra of UFO targets (ref. 14, 15, 16, 17). The system Telescope-Detector-Analyzer (TDA) is intended to be the main opto-electronic unit (ref. 18) which must be used for the data acquisition. In order that the TDA system can be easily guided toward a given target, it is essential to link it with the following tracking and telemetric facilities:

- A Radar tracking station (R), able to search, point and track metal-like (ref. 13) or plasma-like (ref. 12, 13) targets, whose reflected radar mark is typically strong.
- An Infrared Searching and Tracking device (IRST), able to search, point and track a target with a thermal signature.
- A Laser device (L), able to obtain exact telemetry of the target (distance determination) and to serve as a possible "test device".

Such devices can be obtained from military-like technology, which is very well experimented since the ‘70 years (ref. 18).

The most complete TDA system is intended to work in the widest optical spectrum (including near-UV and near-IR), which, ranging from 3500 Å to 11600 Å, is subdivided in 5 main wavelength-windows. The signal data that are acquired by the telescope are recorded on CCD (charge coupled devices) detectors which are used both for direct imaging and for spectroscopy (refs. 2, 5, 7). A Photon-Counting Photometer (PCP) is a supplementary facility (refs. 3, 5, 9). The most ideal and complete TDA system is composed of a complex of 20 small telescopes to which photometric and spectroscopic devices are attached: such an instrumental redundance is required because of the necessity to acquire simultaneous data of 4 different types (2 photometric ones and 2 spectroscopic ones) from all the main 5 wavelength-windows present in the overall 3500-11600 Å spectrum. Therefore, the whole TDA apparatus, constituted of 20 sub-systems, is characterized by 4 main units:

Unit PHOTOM-A - This unit is composed of 5 telescopes, everyone of which is connected with a CCD camera operating in a specific wavelength-window. Every window is obtained by using the following filters of astronomical type: U (3000-4000 Å), B (3700-5500 Å), V (4900-6700 Å), R (5400-9400 Å) and I (7000-11600 Å). In this case one is going to perform CCD Direct Imaging (CCDDI), in order to carry out simultaneously both photography and photometry of an extended (not point-like) light source. Photometry is used in order to measure the light intensity of the source, while photography (in this case of electronic type) is used to measure the light distribution over the light-emitting area of the source.

Unit PHOTOM-B - This unit is composed of 5 telescopes, everyone of which is connected with a Photon-Counting Photometer operating in a specific wavelength-window. Every window is obtained by using the same filters used in Unit Photom-A: U, B, V, R, I. In this case one is going to perform Photon-Counting Photometry (PCP), in order to search for fast light fluctuations, flickerings or pulsations. In this case, only light intensity is measured, not its distribution over the light-emitting area of the source.

Unit SPEC-A - This unit is composed of 5 telescopes, everyone of which is connected with an Objective-Prism, whose dispersing element, a simple prism (ref. 5), is inclined at different angles according to the required wavelength-window. The wavelength-windows are: 3000-4700 Å, 4700-6400 Å, 6400-8100 Å, 8100-9800 Å, 9800-11500 Å. The dispersed light is recorded on CCD cameras. In this case one is going to perform CCD Objective-Prism Spectroscopy (CCDOPS), in order to obtain large-view-field low-dispersion spectra. The indicative value of the obtained dispersion is $d\lambda/dx$ = 100-300 Å/mm. In such a case it is possible to obtain “panoramic spectra” which are directly displayed on the field of the adopted lens or mirror. Such spectra are able to furnish the overall shape of the light spectrum which is comprised in a given wavelength-window and allow one to identify lines (if present) but with no morphologic details.

Unit SPEC-B - This unit is composed of 5 telescopes, everyone of which is connected to a Grating-Slit Spectrograph where light, after entering from a narrow slit passes through a dispersing element, which can be a classical grating or a more sophisticated “grism” (ref. 5): in order to achieve light dispersion in the requested wavelength-window, it is necessary to incline the dispersing element at different angles. The wavelength-windows have the same central wavelength as in Unit Spec-A, but they are restricted to a narrower range (100-300 Å). The dispersed light is recorded on CCD cameras. In this case one is going to perform CCD Grating-Slit Spectroscopy (CCDGSS), in order to obtain medium-high dispersion spectra. The indicative value of the obtained dispersion is $d\lambda/dx$ = 1-30 Å/mm. Such spectra appear as small pieces of the light spectrum which is displayed in the broader wavelength-windows used in unit SPEC-A but furnish precious details on the line profiles, whenever lines are present.

The shutter of the TDA system, which should be necessarily connected with a computer-controlled exposimeter, is intended to work automatically whenever an unidentified flying target is tracked. Repeated frames, both images and spectra, should be taken in fast time-sequence, according to the apparent luminosity of the target. The telescope T is thought to be used to point to far targets. In the cases in which the target is very near, the telescope is intended to be replaced by a Wide-Angle Lens (WAL) by means of a rotating cylinder to which both T and WAL are internally attached at opposite positions; as in the T case WAL can be connected to detectors and to spectrographs as well. The movement of the 4 described units is syncronized with the movement of the R-IRST-L “search, point and track” devices, all working on an altazimuth mounting (referred to horizon coordinates).

In the following section specific instruments, together with observational strategies which are planned to be used, are described in detail.

The Telescope - The use of the telescope depends strictly on the available radar range, which typically, at least for ground-based portable radars, can't exceed 30-40 Km. At this distance an extended strongly luminous object having typical dimensions of 10-50 m is fully in the range of a telescope with an aperture $D \sim 20$ cm. Light-reflection telescopes provide typically very good light gathering power and spatial resolution: this means that light is like amplified and the possible details of target’s surface can be distinguished very clearly. The weight of the telescope should be low enough in order that the whole complex of 20 telescopes plus detection-devices can be easily moved and matched, without appreciable effects of mechanical inertia, with the R-IRST-L tracking system: this is important when “stop and go” effects and/or sudden direction changements of the target motion occur. In order to increase the probability that the target's coordinates, which should be calculated instant by instant by the radar's computer, are fitted suitably with a centered position of the target in the telescope's view-field, the telescope should be of Schmidt-type (ref. 5) which is characterized by a view-field that is wide enough (at least 4° x 4°): in such a way it is possible to reduce the possible effects due to target's random motions and also to radar-guiding inaccuracy.

The Wide Angle Lens - Close UFO targets, if moving, are necessarily characterized by a strong angular velocity and very high luminosity. Therefore, the telescope must be replaced by a Wide-Angle Lens (WAL) having an opening angle which should be varied from 10° to 90° by means of a dedicated zoom system. By using such a device it is also possible to frame possible multiple UFO targets. The WAL lens must also prevent any possible risk of over-exposure of the detectors in the cases in which a very close target with very high apparent luminosity is pointed.

The CCD Detector - To each of 15 of the 20 telescopes (of which: 5 for unit PHOTOM-A, 5 for unit SPEC-A, and 5 for unit SPEC-B), a CCD detector is attached in order to perform both imaging and spectroscopy. The use of the very high capability of a CCD as a light detector and recorder (refs. 2, 7) is justified for an UFO observing program for the following fundamental reasons:

- The high quantum efficiency assures that most incoming photons (50-70%) are recorded. This is just the ideal performance in the case that weakly luminous targets are pointed.
- The high speed of integration allows very short exposure times. This is a clear advantage in the case of very fast moving targets.
- The high dynamic range allows a full capability of exposing correctly and simoultaneously very dark and very bright features of the target which are spatially contiguous, without appreciable under-exposures or over-exposures. This is a favourable performance in the case of not-uniformly illuminated targets.
- The high spatial resolution allows a careful examination of the details of a bright source which is constituted by an illuminated area. This is good in order to be able to study a given luminous target from a morphological point of view.

These reliable CCD performances are well applied both to direct imaging and to spectroscopy. When CCD imaging is carried out, it is possible to obtain an electronic photograph of the target, from which one is allowed to do accurate measurements of the target’s surface details and of the light distribution along chosen axes (technically represented by a Point Spread Function) of the target itself and of its surrounding presumably ionized gaseous medium. When a CCD camera detects dispersed light, using a prism, a grating or a grism, it is possible to obtain an electronic spectrum, by means of which one is allowed to carry out measurements on the continuum spectrum and, in case, to search and identify emission lines or bands. Lines or bands, which may display a particular intensity, equivalent width, base-width and doppler displacement, are the result of atomic transitions which are triggered by particular temperature regimes of a presumably heated target and can be produced by specific chemical elements (refs. 1, 6, 10).

The Photon-Counting Photometer - This light detector owns the precious performance of being highly linear if compared with conventional photographic plates or films: this means that “saturation effects” are restrained in this case. Above all, this is the device which secures the highest time resolution. In such a case one is allowed to detect possible fast target light variations of the order of 10^{-6}-10 seconds: photometric countings obtained with the highest time-resolution (for instance: from 10^{-6} to 10^{-3} seconds) require typically high exposure times (photon integration-times in this case) if the light source is weak. Nevertheless, such a detector, differently from a CCD camera, is not able to record spatially resolved photons (refs. 4, 5, 9). Such a limitation can be overcome if one decides to use the very recent ICCD (Intensified CCD) or EBCCD (Electron Bombarded CCD) detectors, which have performances of both a normal CCD camera and a high-speed photon-counting photometer. Anyway these new devices are not yet fully developed and at present their spatial resolution is still limited to pixel matrixes which are characterized by a small number of pixels (ref. 19): this means that, being the field of sky limited to few primes of arc (instead of some degrees, as required), it can be very difficult to guide the radar-assisted sensors towards the target. However there are good reasons to expect that ICCD and EBCCD detectors, potentially very precious instruments for measurements of UFO light, will be subject to significant progresses during the next years.

The Objective-Prism Spectrograph - By means of an objective prism it is not possible to achieve spectral dispersions better than $d\lambda/dx$ = 100-300 Å/mm (refs. 4, 5). Therefore, in such a case, it is possible to carry out only low-dispersion spectroscopy. An approximately comparable result can be obtained by applying an elementary grating, which is characterized by few lines per millimeter, to the lens of a conventional camera (ref. 21): a similar attempt has been done during previous UFO monitoring programs (ref. 12). In general and in the present case, objective-prism spectroscopy can be fulfilled by trying to track one or more targets together, inside the view-field of a Schmidt-type telescope (refs. 4, 5), in order to obtain spectra which are just displayed on the whole frame. This is a sort of photograph containing dispersed lights instead of simple lights. Spectroscopic frames obtained with an objective prism require typically short exposure times (but longer than in the photometric case) because of the relatively high quantity of photons passing through the dispersing element (prism). The objective-prism device should be used in the following cases:

a) If the target is not hovering on a fixed position.
b) If more than one target is present in the telescope view-field.
c) If a mix of circumstances a) and b) occurs.
d) When the luminosity of the target is too low in order to allow medium or high-dispersion spectroscopy by means of reasonably short exposure times.
e) When the luminosity of the target is high but the target can't be easily tracked in a centered position. In this case it could be impossible to center the target in the dispersion slit of a grating spectrograph for medium-high dispersion.

The Slit-Grating Spectrograph - By means of a slit-grating spectrograph (refs. 1, 4, 5) it is possible to obtain medium-high dispersion spectra. This kind of light-analysis technique can be achieved only when there is sufficient time to place the target in the dispersion slit of the spectrograph. The most favourable circumstance for this occurs when/if the target is standing still. Moreover, in order to obtain an optimum S/N (signal to noise) ratio with the shortest as possible exposure-time, the target must be sufficiently bright, because of the small quantity of photons passing through the dispersing element (grating, or "grism" in the most sophisticated spectrographs) which is used in this case. The slit-grating spectrograph should be indeed used in the following cases:

I. If the target is far away but not too faint and its angular velocity is sufficiently low. In this situation the target can be easily tracked and, consequently, centered into the dispersion slit. In such a case, according to the apparent luminosity of the target, it may be possible to achieve medium-dispersion spectroscopy, which can range approximately from 20 to 50 Å/mm.
II. If the target is very luminous and reasonably fixed. In this fortunate circumstance it should be possible to reach the highest S/N ratio and, consequently, the highest dispersion by using reasonably low exposure times. In such a situation dispersion could be of the order of 1-10 Å/mm. In this case the risk of target over-exposure could be avoided by narrowing in case the slit, or by replacing T with WAL.

III. If the target remains fixed for a reasonable lapse of time and if it is actually looking as a source in which light is distributed over an area (extended source) and not located on a simple point (point-like source), a "scanning mode" could be secured for spectrography. In this case sequential spectroscopic frames could be taken of the whole target by moving the dispersion slit along a chosen axis of the extended luminous source, for instance from the center to the border, including also the possibly excited-ionized surrounding gas.

<u>Costs of a complete TDA system and of less sophisticated systems</u> - The financial cost of a complete TDA apparatus, of the approximate order of 1-2 millions $ according to the requested sophistication level, should be well in the economic possibilities of most nations which have access to advanced technology. Therefore, a TDA-type platform, which should be put at disposal of everyone of these nations, should be installed in all the areas of the world in which the UFO phenomenon appears to be recurrent (ref. 12, Appendix). Anyway, a typical TDA system must not be considered as a fixed station as it is expected that it can be quite easily moved (namely, by trucks, helicopters or transport airplanes) wherever and whenever it is necessary.

A much more basic and cheap apparatus, of the cost of not more than 60.000 $ could be obtained by using the following alternative instruments, most of which are of the advanced amateur type:

1. A low-sophistication or "russian-type" radar for target searching, pointing and tracking (ref. 18). This system would replace completely unit R, while units IRST and L would be excluded.
2. A single CCD camera (ref. 20) connected to a zoom (30-300 mm, typically) telephoto lens, for photometry. This photometric set would replace completely multiple unit PHOTOM-A, while multiple unit PHOTOM-B would be excluded.
3. A single CCD camera (ref. 20) connected to a zoom (30-300 mm, typically) telephoto lens and to an objective prism or to a low-dispersion grating (ref. 21), for spectroscopy. This spectroscopic set would replace completely multiple unit SPEC-A, while multiple unit SPEC-B would be excluded.

It can be noticed that the main disadvantages of such a basic platform would be: general low sophistication, absence of IR and Laser devices, absence of fast photometric facilities and of high-dispersion spectroscopic facilities; moreover it could not be possible to observe all the required wavelength-windows simultaneously. Anyway some results of high scientific relevance could be obtained as well, even if only partially.

Finally, it should be reminded that some important preliminary results could be obtained also by simply applying a low-dispersion grating (ref. 21) to conventional film cameras. The grating facility for films, of the cost of about 200 $, is very easily applicable to normal cameras and it should be used by all the ufologists who, by dedicating their time to "skywatching" activity, operate in the areas of the world in which the UFO phenomenon happens more often (ref. 12, Appendix).

3. Calculated exposure-times for measurements

It is possible to predict the order of magnitude of the Exposure-Time ET in the case one is going to acquire CCD imaging frames and CCD spectroscopic frames of an UFO target. In order to reach this task, it is necessary to define what kind of object one expects to observe. By taking into account all the witnesses and photographs of UFOs (ref. 11, 12, 13, Appendix), it can be reasonable to assume that the "average appearance" of an UFO target is just the one of an "extended object" more or less uniformly illuminated. In such a case, by taking into account all the characteristics of the chosen monitor instrumentation and the physics on which photon detection is based (ref. 5), it is possible to derive the following formula which can furnish a preliminary evaluation of the exposure time ET which is necessary in order to obtain a good S/N ratio:

$$\mathbf{ET}=\frac{\left(\frac{\mathbf{S}}{\mathbf{N}}\right)^{2}\cdot\mathbf{b}\cdot\delta\lambda\cdot\mathbf{Ft}^{2}\cdot\beta^{2}}{\left(\frac{\mathbf{L}}{4\pi\cdot\mathbf{d}^{2}}\cdot\delta\lambda\right)^{2}\cdot\pi\cdot\mathbf{D}^{2}\cdot\mathbf{Dt}^{2}\cdot\varepsilon} \qquad (1)$$

To give an idea of this procedure the following parameters could be arbitrarily fixed:

- UFO diameter D = 10 m (1000 cm).
- UFO shape approximated to a sphere with diameter D.
- UFO distance 100 m ≤ d ≤ 10 km ($10^4 \le d \le 10^6$ cm).
- UFO luminosity L (Watts) assumed to be constant.
- Optimum Signal-to-noise-ratio S/N = 100 (adimensional).
- Sky backgound noise b = 2.5 x 10^{-6} $n_{photons}$ sec^{-1} cm^{-1} $arcsec^{-1}$ $Å^{-1}$
- Telescope aperture Dt = 20 cm (of a typical portable telescope of the *Celestron* or *Meade* type (ref. 22)).
- Telescope focal length Ft = 286 cm (same as above).
- Disk-like dimension for a point-like source (the "seeing") β = 1 arcsec .
- Photometric CCD detector efficiency factor ε = 0.25 .

It is assumed that the wavelength interval δλ is the only variable parameter. The choice of this sole variable is due to the fact that one wants to check how different are the exposure-times according to the kind of observational technique which one wants to carry out. This is synthetized in the following list of options:

1. ta(d) = Very high-dispersion spectroscopy, using δλ = 0.005 Å
2. tb(d) = High-dispersion spectroscopy, using δλ = 0.05 Å
3. tc(d) = Medium-dispersion spectroscopy, using δλ = 0.5 Å
4. td(d) = Low-dispersion spectroscopy, using δλ = 5 Å
5. te(d) = Very low-dispersion spectroscopy, using δλ = 50 Å
6. tf(d) = CCD photometry, using δλ = 500 Å

Results of such calculations are presented in the graph shown in Figure 1. The graph, which furnishes 6 different values of ET for different values of the parameter δλ, is specified for a given value of parameter L, which in this case is assumed to be L = 1 kW (typical and exemplifying value). If one wants to perform photon-counting photometry, instead of CCD photometry one has to assume δλ = 500 Å (as in the case of CCD) and ε = 0.05 (instead of 0.25): in such a case it is possible to obtain an exposure time which is longer of a factor of 5 than in the case of CCD photometry. In the case one wants to decrease or increase of a factor 10 the diameter D or the luminosity L (for instance) of the UFO target, it is easy to see from the formula above that in such a case ET increases or decreases of a factor 10^2.

The assumed 100 m ≤ d ≤ 10 km range for UFO distance is purely indicative. Maximum distance d = 10 km is presented just to show that beyond a certain critical distance, exposure times (in particular, the ones for spectroscopy) aimed at obtaining the best S/N ratio may become prohibitive if the target's apparent luminosity is very low (see formula (1)): such a situation can become serious if one compares the typical short duration of more general UFO phenomena (ref. 13), which is of the order of seconds or minutes, with the required long exposure times which are necessary in order to monitor very distant or weakly luminous targets. Therefore, it is reasonable to assume an ideal critical distance d = 1 km in order to carry out with best success (namely, with S/N = 100) the following two fundamental types of observations: (a) conventional photometry (CCDDI) and low-dispersion spectroscopy (CCDOPS) of short-lasting and/or weakly luminous UFO phenomena; (b) fast photometry (PCP) and high-dispersion spectroscopy (CCDGSS) of typically very luminous objects such as the Hessdalen-like phenomena (ref. 12), which have been sometimes reported to last for times as long as 2 hours and whose luminosity could be comprised between 1 kW and 100 kW. On the contrary, conventional photometry of Hessdalen-like phenomena could be carried out up-to a target distance d ≥ 10 km. Anyway it is very important to point out that these apparent distance limitations must not be intended so strictly, as observations of very distant (up to 50 km) or weakly luminous targets can be carried out as well, but with the expectation of obtaining a low or very low S/N ratio, such as 10 or 5; nevertheless, just as in the standard case of the observation of very faint astrophysical objects such as “white dwarf stars” or “extragalactic sources” (ref. 6), this low S/N value may be often sufficient (even if not ideal at all) in order to extract data of some physical value.

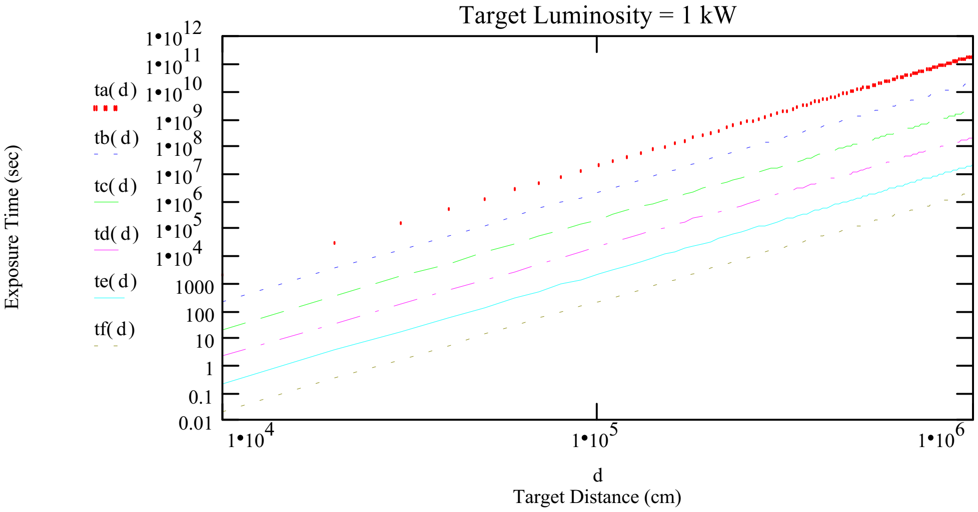

Figure 1. Exposure times for a UFO target with luminosity L = 1 kW, given δλ = 0.005 Å (ta), δλ = 0.05 Å (tb), δλ = 0.5 Å (tc), δλ = 5 Å (td), δλ = 50 Å (te), δλ = 500 Å (tf). Target diameter is assumed to be D = 10 m. Distance d is varied from 100 m to 10 Km. Graph is plotted on bi-logarithmic scale.

4. Physics from data analysis and research strategies

Output processed data are expected to furnish the following measurable parameters:

A. Geometric and Kinematic Parameters.
B. Photometric Parameters.
C. Spectroscopic Parameters.

The derivation of physical quantities by means of multi-wavelength and multi-mode instrumentation needs specific choices of physical parameters and aimed strategies for obtaining them. Proposed choices and strategies are described in the present section.

A. Geometric and Kinematic Parameters

- *Distance d* - The distance d of the target is intended to be obtained straight by means of radar tracking, coupled, in case, with laser telemetry (ref. 18). This measurement is of basic importance in order to convert apparent physical and geometric dimensional quantities into intrinsic measurements of the target. Distance measurement is expected to be updated every time-unit.

- *Linear Height h* - The linear height h can be calculated by relating d with the angular height ϕ, as:

$$\mathbf{h = d \cdot \sin\phi} \qquad (2)$$

Angular height is an altazimuthal quantity (namely, based on the horizon system) which can be inferred from the target position, being target position obtained from the radar facility.

- *Linear Size S* - The linear size S can be calculated by relating the angular size α, which is determined straight by taking measurements on a given CCD frame, to the target distance d, as:

$$\mathbf{S = d \cdot \tan\alpha} \qquad (3)$$

- *Linear Separation Z* - The linear separation Z of two close targets can be calculated by relating the angular separation θ, which analogously to α is determined straight by obtaining measurements from a given CCD frame, to the target distance d. Z is given by:

$$\mathbf{Z = d \cdot \tan\Theta} \qquad (4)$$

In general, the possibility to obtain the quantities S and Z is strictly dependent on the spatial resolution capability of the CCD camera (refs. 2, 4, 7). For this reason it is important that the CCD sensor can be built up by using a pixel matrix which is characterized by great dimensions and composed of single pixels with small dimensions.

- *Transfer Velocity V* - The transfer velocity V of the target can be calculated by determining by means of radar the time t taken by the target to reach two contiguous points and then relating t with the respective measured distance d.

B. Photometric Parameters

A measurable CCD image of a target of UFO type can be intended to be an “extended source” (here approximated to a sphere) subtending a solid angle Ω and having a superficial intensity B at a given frequency interval $\Delta\nu$. Therefore, superficial flux F in the same interval is given by:

$$\mathbf{F_{\Delta\nu} = \int_{\Omega} B_{\Delta\nu} d\omega} \qquad (5)$$

where, ω being the infinitesimal element of solid angle Ω, the integral is extended to all the apparent surface of the source. This is a measurement of the apparent luminosity of the target (ref. 6) which one is able to achieve after processing a given CCD photometric frame.

- *Intrinsic Luminosity $L_{\Delta\nu}$* - Relating the superficial flux $F_{\Delta\nu}$, measured by means of CCD photometry, with the distance d, obtained by means of radar and/or laser telemetric facilities, one is then able to calculate the intrinsic luminosity $L_{\Delta\nu}$ of the target, as:

$$\mathbf{L_{\Delta\nu} = 4\pi \cdot d^2 \cdot F_{\Delta\nu}} \qquad (6)$$

- *Color Index δL* - The color index is defined in this case as $\delta L = L_{\Delta\nu 1}/L_{\Delta\nu 2}$, where $L_{\Delta\nu 1}$ and $L_{\Delta\nu 2}$ are two intrinsic luminosity values which are obtained in two different frequency intervals. By using the available U, B, V, R, I filters (ref. 6), it is finally possible to obtain the intrinsic luminosities L(U), L(B), L(V), L(R), L(I) and then determine the color indexes L(U)/L(B), L(B)/L(V), L(V)/L(R), L(R)/L(I). This measurement is very similar to the one which is normally obtained from classical astronomical observations aimed at the construction of Hertzsprung-Russell diagrams (ref. 6).

- *Intrinsic Superficial Intensity $I_{\Delta\nu}$* - Intrinsic superficial intensity $I_{\Delta\nu}$ is related to the superficial intensity $B_{\Delta\nu}$ using the relation:

$$\mathbf{I_{\Delta\nu} = 4\pi \cdot d^2 \cdot B_{\Delta\nu}} \qquad (7)$$

In particular, $I_{\Delta\nu}$ is considered to acquire the same value in concentric isophotal contours by which the whole surface of the luminous target is subdivided. In order to obtain $I_{\Delta\nu}$ one is obliged to do "differential photometry" of an extended target having a linear size S. Such measurement consists in calculating, at a fixed frequency range $\Delta\nu$, the intensity gradient $dI_{\Delta\nu}/dr$, where r is defined in the range $0 \leq r \leq S/2$. This one is strongly considered a fundamental task as one may well expect that the intrinsic superficial intensity of an UFO target is not uniform all over the emitting area (ref. 18). Measurement of the intensity gradient requests for two variants, namely $dI_{\Delta\nu}/dr$ and $d\delta I/dr$, where δI is a color index which is expressed as the ratio of the intrinsic superficial intensities in two different wavelength ranges. In few words, the measurement of the intensity gradient of an UFO target consists in determining how the light intensity and the color are distributed over the whole illuminated surface by assuming that these parameters can get different values from the center to the edge of such a surface. Regarding this, four extreme cases can be cited as examples: a1) the UFO light is all concentrated in the center; b1) the UFO light is all concentrated in an external ring; a2) the UFO color is bright yellow in the center and dark red in the external edge; b2) the UFO color is dark red in the center and bright yellow in the external edge. All these extreme cases, together with smoother variants, have been reported from UFO witnesses (ref. 13). Isophotal contour measurements and related physical parameters are commonly in use in the astrophysical research regarding extended celestial objects such as galaxies, nebulae or planets (ref. 6).

- *Total Luminosity L_T* - If one wants to evaluate the total luminosity L_T of a given UFO target, it is necessary to integrate intrinsic luminosity values over the overall observational band, which can range from ν1 = 3500 Å to ν2 = 7500 Å in the optical, but which can be also extended in case in the near UV and in the near IR. In such a case one obtains:

$$\mathbf{L_T = 4\pi \cdot d^2 \cdot \int_{\nu 2}^{\nu 1} F_{\Delta\nu} d\nu = 4\pi \cdot \left(\frac{S}{2}\right)^2 \cdot \sigma \cdot T_E{}^4} \qquad (8)$$

where, in particular, σ is the Stefan-Boltzmann constant, and T_E is the effective temperature of the target (ref. 6). It is very easy to notice from the formula above that, after obtaining measurements of L_T and S following the procedures described in the previous sections, it is then possible to deduce the effective temperature of the UFO target. Temperature measurement is allowed only if one is able to ascertain, by means of spectroscopic measurements of the continuum spectrum and by doing suitable comparisons with Planck theory (ref. 6), that the UFO target is emitting as a thermal spectrum. The measurement of total luminosity (or bolometric luminosity) L_T is normally expected to be done, when possible, in the case of celestial objects of every type, when multi-wavelength observations are available (ref. 6).

- *Period of Pulsation Pp* - If one is able to obtain a large number of CCD frames (for instance, 100-200 frames) of a given target during one single observational run, it is then possible to measure, at a fixed frequency range Δν, the period of pulsation P_p (if present). P_p (ref. 9) involves the pulsational time-variation of the intrinsic luminosity $L_{\Delta\nu}$, of the intrinsic intensity $I_{\Delta\nu}$ and of the color index δL. This means that in the real case the following situations could be present: a) the UFO light is pulsating all over its surface; b1) the UFO target has a central pulsating light; b2) the UFO target has an external pulsating ring-shaped light; c) the UFO color is continuously changing (periodically or a-periodically); d) a mixture of the previous situations occur. All these variants of UFO pulsation have been reported by many witnesses (ref. 13). As one may well expect that a possible pulsation could also range from 0.001 seconds to some minutes, it is realistic to assert that a CCD camera is not the most suitable photometric device which can be able to detect fast periodic pulsations, just because of the long read-out times (about 20 seconds) of this device. Therefore, in order to perform efficiently this research of "target pulsation" one should couple to the CCD observing mode an additional and intensive use of photon-counting fast photometry. Search and consequent measurements of pulsation effects are strongly encouraged, as previous professional observations of pulsating UFO targets have been already done in the past, such as in the case of the measurements attempted by Project Hessdalen in 1984 (ref. 12).

- *Angle of Gravitational Deflection GD* - Not few witnesses of UFO sightings report the apparent evidence of “curved light-beams” in proximity to an UFO (ref. 13). Even if the origin of these phenomena could be due to a physical effect which is not yet included in the known laws of physics, by now one is inevitably tempted to try to explain such a phenomenology in the context of known theoretical physics by hypothesizing that the UFO target itself is able to generate an Einstein-Schwarzschild autonomous gravitational field, which could be supposedly generated by a natural or artificial mini-black hole or by a locally warped space-time (refs. 6, 8). According to the general relativity theory, the light path of a luminous source which passes close to such a strong field is necessarily deflected by an angle GD. This theoretically predicted effect is not any more only a mathematical exercise, but, since the last ‘80 years, it has been observationally proved in form of “gravitational lensing effects” in the case of very large-scale phenomena which are of astrophysical interest: the case of extragalactic massive objects deflecting with a lens-like effect the light of field galaxies is illuminating (refs. 23, 24, 25). However no proof of such an effect has been found yet in the case of much smaller-scale phenomena such as UFOs. Therefore, for the present scope of the proposed monitoring project, the measurement of angle GD (if really present) could be attempted in 2 ways:

a) In the case of night-time observations, a CCD image of an UFO target is expected to contain a certain number of field-stars. For this reason it should be necessary to compare the CCD frame in which the UFO is present with a CCD frame of the same field of sky containing only stars. One should expect that the path of the photons of the stars which are closer to the UFO are deflected by an angle GD from their real path because of a “gravitational lensing effect” and that, if the gravitational focus comes close to the TDA apparatus, the received light of the "perturbed stars" may be highly strengthened. By comparing the two CCD frames (the target frame and the control frame) it should be possible to verify that the star positions can be changed from real positions and that starlight may look to be amplified.
b) An alternative experiment for measuring the angle GD could be carried out by pointing the beam of the laser device to varying distances (perpendicular to the line of sight) from the UFO target and by taking simultaneously fast sequential CCD photograms of the field of sky which contains both the target and the laser beam. If the laser beam appears to be deflected, one can easily measure the angle GD by doing subsequent processing of the CCD frames and determine how much this angle increases when the distance of the laser beam from the UFO increases.

Conversely, if one hypothesizes that the given UFO object is able to generate an “anti-gravitational” field, it could be expected that the angle GD is deflected in the opposite sense. Similar measurements as the ones described in points a) and b) could be consequently carried out.

- *Gravitational Redshift GR* - Following the hypothesis discussed in the previous topic, a new test could be proposed. In such a variant, it can be supposed that, in addition to gravitational deflection, the photons emitted by a light source that is very near to an Einstein-Schwarzschild gravitational field (just the photons emitted by the excited-ionized and brightening atmospheric gas which surrounds presumably the luminous target), which is supposedly generated by an UFO target, are subject to a gravitational red-shift GR (refs. 6, 8). In order to measure GR, one must know the contribution of GR to the color index of the target. Conversely, hypothesizing that the target is able to develop an “anti-gravitational” field, it may be expected that one record an anti-gravitational blue-shift .

C. Spectroscopic Parameters

On the basis of the physical configuration of a possible UFO target, one should expect to detect different types of spectral features. The target itself or its surrounding medium or both must present proper excitation and/or ionization conditions. This implies the existence of the following possible scenarios:

A) The target itself is a heated solid object.
B) The surrounding atmospheric gas is heated by the central target by means of some exotic mechanism.
C) Both situations occur.
D) The target iself is a hot plasma.

I. In the case the UFO target itself is a machine whose external surface is heated by some propulsion mechanism, one may assume that such a target is able to produce molecular emission bands of various strengths, which are possibly resulting from atomic transitions in metallic elements. Such emission bands are expected to be mixed with oxygen and nitrogen emission lines produced by the excitation-ionization processes to which the surrounding atmospheric medium is subject because of the very hot central target. The strength of both the emission bands and of the atmospheric emission lines should depend on the involved temperature of the heated source and on the density of both the heated source and its surrounding gaseous medium. At low altitudes, where airmass is thicker one should expect to record stronger atmospheric emission lines.

II. In the case the UFO target doesn't appear to be a hot machine (no metallic lines) but its surrounding medium is hot, one should expect to record only atmospheric emission lines. Maybe one of the causes of such a situation could be due to a pulsed magnetic field whose pressure acts, at every given instant and at every given point, as a magnetically-induced thermal shock on the atmospheric medium (ref. 14). If this is the case one could also expect that microwaves are emitted; in such a case microwave radiation could be detected with an appropriate additional device.

III. In the case the UFO target is itself a hot plasma, it is expected that one records emission lines resulting from atmospheric gas ionization and excitation.

- *Thermodynamic Parameters* - From the measurement of the equivalent width (energy which a line extracts from the continuum) and of the full width at half maximum of every emission line or band, one is then able to derive the main thermodynamic parameters - the temperature T, the pressure P and the density ρ (refs. 1, 6, 10) - of the target and, in most cases, of the excited-ionized atmospheric gas. In the case the spectrum of the luminous target doesn't present emission lines, one can measure the target temperature directly from the continuum spectrum. As it is expected that a thermal continuum spectrum reproduces more or less strictly a bell-shaped Planck curve (ref. 6), it is necessary to determine the precise wavelength λ_{max} at which the intensity of the continuum spectrum reaches the highest value. By using this procedure temperature T can be derived from the *Wien law* (ref. 6):

$$\boldsymbol{\lambda_{max} \approx 0.29 \cdot T^{-1}} \qquad (9)$$

In such a case the acquisition of a low-dispersion spectrum can be considered sufficient for a preliminary measurement of T.

- *Transfer Velocity V_{rad}* - If the target is moving very fast, the center of the emission bands can be displaced by a quantity given by the doppler shift:

$$\boldsymbol{\Delta\lambda = \pm (\lambda_{ufo} - \lambda_{lab}) = \pm (\lambda_{lab} \cdot V_{rad}) / c} \qquad (10)$$

where c is the velocity of light, λ_{ufo} is the observed blue or red-shifted wavelength of the center of the emission band produced by the target, λ_{lab} is the wavelength of a laboratory band at rest and V_{rad} is the radial velocity of the target (refs. 1, 6). This method for determining the transfer velocity is intended to be strictly coupled with the radar method. Because of the very high-precision requested, such a measurement can be secured only with medium or high-dispersion spectroscopy. On the contrary, the emission lines which are due to heated atmospheric gas are not expected to show any radial doppler displacement, as the excitation-ionization processes which are due to atomic transitions of the luminous target surrounding medium take place only when the target crosses a given point of a quasi-steady atmosphere at a given instant. Atmospheric emission lines could only be broadened by gas turbulent motions (refs. 1, 6, 10), which can be a mixture of normal atmospheric turbulence and a possible “turbulence factor” which may be induced by the target's hot surface or by another kind of target heating source.

- *Rotational Velocity V_{rot}* - If the target itself is rotating fast, one could be able to observe emission bands whose profile is rotationally broadened by a Doppler factor given by the formula:

$$\Delta\lambda = \pm (\lambda_{lab} \cdot V_{rot} \cdot \sin i) / c \qquad (11)$$

where V_{rot} is the rotational velocity of the target and i is the inclination of the rotation axis in comparison with a plane which is normal to the line of sight (ref. 6). If the surrounding ionized gas is rotating as well, it could be possible to record atmospheric emission lines whose profile is rotationally broadened by the same doppler factor given above: this feature would be a clear indication of a "vortex regime" present in the atmospheric gas, which is triggered by the central rotating target. If the target itself is a strongly rotating plasma concentration one could possibly record highly rotationally broadened atmospheric lines.

- *Infall Velocity V_{in}* - In the case some atmospheric gas is collapsing toward the target, one could record atmospheric emission lines which are red-shifted in comparison with the laboratory lines, as the infalling atmospheric gas should depart from the observer. This could happen if the atmospheric gas is subject to a strong local gravitational field whose source is the UFO target itself.

- *Magnetic Field Intensity B* - In addition to be thermally broadened by the predictable high temperature regime (ref. 6), which can cause also micro-turbulence into the perturbed gas, the emission lines can be subject to the Zeeman splitting effect because of the action of a magnetic field (refs. 1, 6, 10). In this case every single emission line is expected to be separated into a number of components which are differently polarized according to the orientation of the magnetic field in comparison with the direction of the observer and whose separation depends on the intensity B of the magnetic field. If it is possible to obtain a S/N ratio which is high enough and if the target is reasonably fixed (or semi-fixed), in which case it is possible to carry out high-dispersion spectroscopy, one is allowed to get a good measurement of the magnetic field intensity B of the target.

- *Period of Pulsation P_p* - In the case in which sequential CCD spectrographic frames of a single target are able to furnish a great number of spectra at a very short time-distance the one from the other - for instance by using an indicative time-sequence of 20-30 seconds if the target is very luminous - and assuming to be in the right conditions to carry out medium-high dispersion spectroscopic measurements, one could try to verify if the measured spectroscopic parameters - in particular the magnetic field intensity B - are subject to some kind of pulsation effect.

5. Time-variability of the physical parameters

Physical quantities deduced from data processing are of little utility if one considers them separately. The investigated problem can be fully understood only if all quantities are connected together in a dynamical mode. For this reason one is necessarily induced to search for significant correlations between the measured parameters, on the basis of the detection of time-variable features. Possible time-variability of the UFO phenomenon can furnish enlightening explanations on its physical mechanism. This task can be achieved if one succeeds in acquiring a large amount of CCD frames - both photometric and spectroscopic - when/if the trajectory of the target can be tracked for a reasonably long observational time. For instance, if the target is very luminous and can be kept centered in the telescope view-field for a duration of 30 minutes, one could obtain typically 100-200 CCD frames in fast sequence, by taking into account the fact that the computer-controlled exposure time may change drastically if the UFO distance changes. An analogous study of time-variability can be achieved by means of a simoultaneous use of photon-counting photometry: in this case the PCP unit should be pointed to the target for the whole duration of the phenomenon.

The time-variation of the two following parameters must be previously ascertained:

- *The Linear Size S* - This measurement is justified by the previous collection of some witnesses of UFO events (ref. 13), regarding, on the basis of visual-suggestive stimulus, possible variations of the dimensions of UFOs which are standing still.

- *The Intrinsic Luminosity* $L_{\Delta\nu}$ - As in the previous case it is necessary to perform also this measurement, as reliable witnesses of UFO sightings report luminosity variations of UFOs which are standing still (ref. 13).

Furthermore and most importantly, according to the large amount of witnesses collected so far (ref. 13), there is the suspect that the time-variation of the transfer velocity of an UFO target may be correlated to analogous time-variations of the following physical parameters:

- *The Color Index* δL - Reliable witnesses of UFO sightings describe UFO colors turning from blue-white in static or quasi-static configurations to red during fast accelerations. In other cases, witnesses describe the opposite behaviour (ref. 13).

- *The Period of Pulsation Pp* - Reliable witnesses of UFO sightings describe emitted light which is characterized by a variable pulsation period when the velocity increases (ref. 13). In such a case it is necessary to measure the quantity dP_p/dt, where t is the variability time-scale.

- *The Intensity Gradients* $dI_{\Delta\nu}/dr$ *and* $d\delta I/dr$ - As one may well expect the occurrence of a particular "slope factor" $s_{\Delta\nu}$ for each curve $I_{\Delta\nu} = f(r)$ and $\delta I = f(r)$ (for $0 \leq r \leq S/2$) regarding the intrinsic specific intensity and the color index respectively, it is of fundamental importance to be able to evaluate the quantity $ds_{\Delta\nu}/dt$, which is defined as the time-variation of $s_{\Delta\nu}$ at every given wavelength-window (U, B, V, R, I). In particular, one could develop this study by measuring, at every given instant, the ratios s(U)/s(B), s(B)/s(V), s(V)/s(R), s(R)/s(I) and s(U)/s(I). By adopting this procedure, one could achieve a compact method for studying the possible time-variation of the surface light distribution of an UFO target. This measurement is justified by the fact that time-variability of surface light distribution of UFOs has been often reported by witnesses (ref. 13).

- *The Angle of Gravitational Deflection GD* - Some witnesses tell about the sighting of "curved lights" which seem to have been produced by some UFOs and which occasionally change their curvature angle (ref. 13). Following descriptions reported by witnesses on this phenomenology, repeated CCD images, containing both the UFO target and a laser beam which is pointed at a fixed very short distance from it, could be taken during the whole length of the sighting, in order to measure the possible time-variability of the angle GD when the UFO is hovering, landing, standing on the ground, taking off, accelerating and decelerating.

- *The Gravitational Redshift GR* - The variation of parameter GR could be inferred from its contribution to the time-variation of the color index.

- *The Rotational Velocity Vrot* - Many witnesses of UFO sightings have had the impression that some UFOs were rotating more or less fast and that the rotation rate increased with the transfer velocity of the UFO (ref. 13). Such a witness report could be accurately confirmed by acquiring spectroscopic measurements of the possible time-variation of the rotational velocity parameter.

- *The Magnetic Field Intensity B* - EM interference effects on electric devices (ref. 13) together with some neurological and physical effects (ref. 13) affecting witnesses who approached occasionally an UFO which was standing still, suggest that UFOs are surely surrounded by a strong magnetic field. Therefore, it could be possible to measure the time-variation of the magnetic field intensity B when a given luminous UFO target is accelerating or decelerating, or when the emitted light is increasing or decreasing. This measurement could be obtained by carrying out sequential CCD high-resolution spectroscopic frames of an UFO target.

6. Conclusive remarks

The search for time-correlations between the discussed measurable physical parameters could surely shed light on the physical mechanism which creates the UFO phenomenon. The knowledge of such a physics could allow one to establish definitively if UFOs are previously unknown natural phenomena or machines characterized by a specific propulsion device. For instance, since now, it is necessary to pose some fundamental questions such as:

A. Are there correlations between the transfer velocity, the intrinsic luminosity, the color index, the magnetic field intensity, the rotation rate and the period of pulsation of an UFO?
B. Is an UFO able to produce a local gravitational field and/or a local anti-gravitational field and to alternate these two forces?
C. Which relation exists between the magnetic field produced by a given UFO and its local gravitational field, if present?

Before venturing carefully prepared hypotheses, it is of fundamental importance to collect the largest as possible amount of data by securing the following two simultaneous observational strategies:

I. Target monitor using a wide range of wavelength-windows.
II. Target monitor carried out by means of a wide range of detecting devices.

In particular, astronomers should try to infer what is acting inside an UFO, by studying the quality, the quantity and the variability of the continuum and discrete radiation which is emitted, in the same way in which these scientists are able to understand the physics of a star interior by studying the observed properties of a star atmosphere. This intriguing problem is still open and the technology for studing it is now fully available.

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27. http://antwrp.gsfc.nasa.gov/apod/ap950711.html
28. http://www.astro.indiana.edu/scaamp/projects/Grav_Lenses/gravlens.html
29. http://vela.astro.ulg.ac.be/themes/extragal/gravlens/bibdat/gldb/search_e.msql

APPENDIX: Some examples of recurrent UFO phenomena on the Web

- The Hessdalen lights in Norway

http://hessdalen.hiof.no/
- The Marfa lights in USA

http://www.marfalights.com/gallery.html
- The Yakima lights in USA

http://www.nwmyst.com/nwmyst-ufo-0025.html
- The Ontario lake lights in Canada

http://members.tripod.com/~FieryCelt/ORB.html
- The Pine Bush lights in USA

http://www.monmouth.com/~bcornet/
- The Tagish Lake lights in Yukon (Canada)

http://www.ufobc.org/yukon/tagish.htm
- The Ural lights in Russia

http://www.ufo.ural.ru/
- Some other russian lights

http://www.anomalous-images.com/images/myst005.jpg
- The Piedmont lights in USA

www.news-observer.com/daily/1997/05/24/nc05.html
http://ourworld.compuserve.com/homepages/AndyPage/RUTLEDGE.htm
- The Pennine Mountains lights in Great Britain

http://www.hauntedvalley.com/lightsinfo.htm
- The Min-min lights in Australia

http://www.hiof.no/ia/prosjekter/hoit/html/nr2_96/erling_i_australia.html
- The Victoria lights in Argentina

http://webs.sinectis.com.ar/rdva/
- The Hardin (Ohio) ligths in USA

http://users1.ee.net/pmason/hardin_photos.html

NOTE 1

This work is the expanded and revised version of an invited paper which the author presented at:

***THE FIRST INTERNATIONAL WORKSHOP ON THE UNIDENTIFIED ATMOSPHERIC LIGHT PHENOMENA IN HESSDALEN** - Hessdalen, Norway, 23-26 March 1994.*

More informations on this valuable workshop, organized by Prof. Erling P. Strand of the Department of Informatics and Automation of the Østfold College - Sarpsborg (Norway), can be found at the web site: http://hessdalen.hiof.no/

NOTE 2

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BRIEF CURRICULUM OF THE AUTHOR

Massimo Teodorani (born in october 31, 1956) is an astrophysicist from Emilia-Romagna (Italy). He owns a master degree in astronomy and a Ph.D. in stellar physics both obtained at the Bologna University. He worked at the Bologna and Napoli Observatories, as a specialist in the observational and interpretative research on the non-stationary behaviour of stars such as supernovae, novae, cataclysmic and symbiotic stars, high-mass close binary stars, black-hole candidates and eruptive T Tauri stars. He deeply experienced photometric and spectroscopic observations by using several optical telescopes and the IUE ultraviolet satellite. At present he is a scientific advisor of CNR (Consiglio Nazionale delle Ricerche) in astrophysical subjects and SETI. As a parallel research, since 10 years he actively carries out investigations on "anomalous luminous atmospheric phenomena", of which he planned the techniques for obtaining measurable physical parameters. Moreover, he analyzed multi-wavelength instrumental data in order to prove or reject canonical and non-canonical theories regarding such phenomena. As a scientific supervisor of the Italian Committee for Project Hessdalen, he is currently working on a geo-topographic map describing the world areas of recurrence of the luminous phenomenon by collaborating with various researchers in the world, in particular with "Project Hessdalen" in Norway. He published several peer-reviewed papers both in astrophysical journals and in journals of scientific level regarding studies on “anomalies”, and he constantly gave presentations of the technical results of his research at recognized scientific institutions. He is a member of various scientific societies.