



Investigation & analysis of transient luminous phenomena in the low atmosphere of Hessdalen valley, Norway

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ABSTRACT

For over 100 years, transient luminous phenomena have been seen in the Hessdalen valley. Italian and Norwegian scientists, gaining experience from the SETI program, has since 1998 installed cameras, spectrometers and RADAR's to unveil the nature of this phenomenon. Results indicate a combustion process driven by an unknown power source.

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1. Introduction

During the last 25 years researchers have tried to explain the nature of the transient luminous phenomena which have been observed in the low atmosphere above the Hessdalen valley. The valley is located in the middle of Norway, 120 km southeast of Norway's old capital city Trondheim at latitude 62° 41' North and longitude 11° 12' East between two mountain ranges, stretching out 15 km in north-south direction at an altitude of 600 m. In the south, at 800 m altitude, the lake Øyungen gives birth to the river Hesja, which runs through the center of the valley towards north.

Two thousand years ago inhabitants dug out bog iron from surface mines scattered all over the valley. Several copper mines are also situated inside this small valley, and one of Norway's biggest ore deposits is found in the southern part, where several hundred tons of species of ore, copper and zinc, still awaits to be excavated. The

climate is humid and rainy during summertime, and sub arctic in wintertime.

During the winter of 1811, the priest Jakob Tode Krogh wrote in his diary: "In the last days of the year 1811 a star with big shining brushwood's was seen on the sky. It gave away a huge glare..." [1]. In 1895 the newspaper "fjeldljom" [2] reported about strange lights in the valley, and during the Second World War people saw lights in the valley [3].

After the war, very few lights were seen until 1982. This time the lights were so intense and frequent that they became a tourist attraction. This attracted interest among scientists, and in 1984, Strand conducted a research campaign.

Instruments used during the campaign were:

- (1) Camera with grating for optical spectrum analyzers.
- (2) Infrared viewer.
- (3) Spectrum analyzer scanning receiver sensitive to electrical field 10 KHz–1GHz.
- (4) Seismograph for detecting crust in the earth/earthquake.
- (5) Geiger counter for detecting radio activity.

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- (6) Magnetograph for detecting variations in earth magnetic field.
- (7) Radar.

In one single week, 53 observations of unexplainable light phenomena were obtained, several confirmed by radar. The existence and nature of the phenomena were documented in a report by Strand [4].

2. Theoretical models

While the number of observations was dropping after 1985, the findings in Strand's report were slowly accepted by the scientific community. In 1994, the first international conference about the Hessdalen phenomenon took place. The aim of the conference was to address the need for theoretical models and predictions used to guide development of equipment and methods for studying the phenomenon. Fourteen papers were presented, and 27 scientists from 8 different countries attended the conference, which was held in the Hessdalen valley. Professor Boris M. Smirnov reported about the results of the conference in *Physics Uspekhi* [5]. He concluded that the Hessdalen lights were real natural phenomenon, which at present time could not be explained by main stream physics. Seven physicists presented theoretical models for the Hessdalen phenomenon, among them Professor B.M. Smirnov, who connected it to Ball Lightning physics. Using the 1984 data from Strand, Dr. Zou [6] found significant evidence for a rotating or vortex plasma, and a fireball model based on wave-particle interactions. This model was able to explain the high velocities of the phenomenon, measured by radar to over 8000 m/s, observed in 1984 by Strand. However, a detailed physical explanation was not given, partly due to the lack of data and to the difficulties in nonlinear atmospheric plasma physics.

Another theoretical model, introduced by Dr. Fryberger [7], proposed a vorton-antivorton plasma model, where the energy and long living time of the Hessdalen phenomenon derives from nucleon decay catalyzed by this plasma. He made several predictions of radioactive and electromagnetic radiation. New observed data did not emerge during the conference, but several new theoretical models turned up. These were divided in two groups, as in Ball Lightning physics, models with external or internal energy sources.

Externally powered models incorporated electromagnetic radiation from outside, combined with ordinary transmission line theory, where the valley is described as a 15 km long and 5 km wide transmission line. Here a standing wave creates a strong electrical field, huge enough to ionize the air and send out energy as light. The light ball is created by the electrical field and does not move; the field moves along and ionizes the air in its path. This model also explains the high velocities observed by Strand in 1984, 8000 m/s, and abrupt movement which seem to violate the law of inertia, if the phenomenon has any significant mass. See Fig. 1. The electrical field might have been produced by tectonic stress, but the light's long

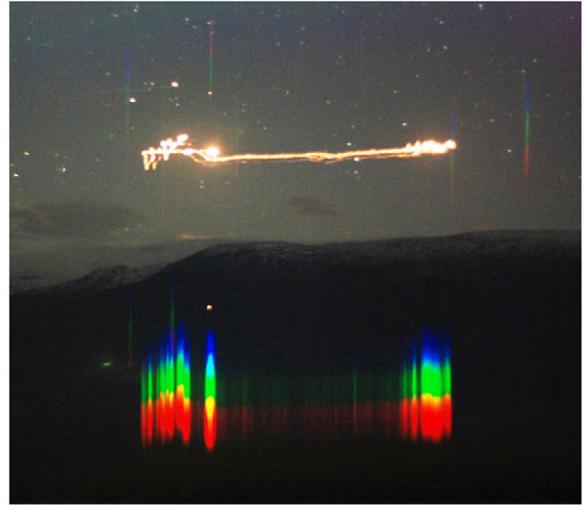


Fig. 1. Hessdalen phenomena and optical spectrum 20th September 2007 21:58.

duration, 2 h, makes this explanation unlikely. No one of the proposed models was alone able to fully explain the complex nature of the Hessdalen phenomena. The proposed theoretical models were:

- Internal energy:
 - (1) ionized fractal gas concentration, Smirnof,
 - (2) ionized gas contained by a self-restricted electrical field, Arnhof,
 - (3) ionized vorton-driven gas concentration, Fryberger,
 - (4) ionized gas concentration driven by fast-pulsating EM field, Protasevich.
- External energy:
 - (1) standing waves created by atmospheric EM microwaves, Manykin,
 - (2) atmospheric electricity as seen in St.Elmos fire, Grigorev,
 - (3) wave-particle interaction creating plasma vortices and solutions, Zou,
 - (4) earth lights created by tectonic stress, Deveraux.

All the theoretical models had to be considered, and astrophysicist Dr. Teodorani worked out a suggestion for experimental methods to verify the different theories [8].

3. Instruments and methods

The conference addressed the need for new instrumentation and more data, which attracted the interest from Dr. Montebugnoli, director of the Medicina Radiotelescope, at the Italian Institute of Radioastronomy, IRA, in Bologna. A research program called project EMBLA was developed in cooperation between Østfold University College in Norway and Institute for Radioastronomy in Bologna Italy. The aim of project EMBLA [9] was to extract new data from the Hessdalen phenomena in the radio

frequency field, by the use of spectrum analyzers used in radio astronomy, in radio frequency monitoring systems and in the SETI program. This involved development and installation of an autonomous research station in the Hessdalen valley. In 1998, a blue steel $3 \times 3 \times 3 \text{ m}^3$ container, named BlueBox, was purchased and rebuilt for this purpose by Norwegian students and scientists see Fig. 2.

While Italian researchers, lead by Dr. Montebugnoli, investigated the results obtained in the design of fast data acquisition and processing systems for SETI, the installed high resolution spectrometers and the UHF radar equipment. Radio frequency monitoring systems was installed by the Italian researchers during the summer of 2000, and by the end of 2002 two radar systems was installed in the BlueBox. The systems consisted of a 2 kW 10 GHz Raymarine maritime radar and a directional UHF low power pulsed radar for studying atmospheric phenomena. The UHF atmospheric radar was later moved to the farm of Skogås to gain visibility. The following instruments have been installed in the BlueBox [10]:

- Equipment installed in BlueBox by the Institute of Radioastronomy, IRA, Italy:
 - (1) ULFO, ultra low frequency observer.
VLF-ELF correlation receiver and spectrometer connected to two loop antennas sensitive to magnetic field in 1–14 KHz range.



Fig. 2. Autonomous research container nicknamed BlueBox.

- (2) INSPIRE, interactive NASA space physics ionosphere radio experiment.
VLF receiver and spectrometer connected to a dipole antenna sensitive to electric field in 1–20 KHz range.
- (3) SS-5 and SENTINEL-1 spectrometers.
Two spectrometers connected to a 1420MHz receiver with 5 and 10 MHz bandwidth and 10 Hz and 10 KHz resolution, respectively. Receiver is coupled to a vertical omni directional antenna.
- (4) Spectrum analyzer, Hewlet Packard.
Scanning receiver sensitive to electric field in the 0.1–1.8 GHz range. Connected to a wide band omni directional antenna.
- (5) UHF low power pulsed RADAR [11].
Directional 440 MHz radar for atmospheric phenomena investigation.
- Equipment installed in BlueBox by the Østfold University College, Norway:
 - (1) Motion sensitive CCD computerized video camera system.
Whenever a new light or event is detected by the computer system, a Black & White alarm picture is taken and displayed on Internet while video recorders starts and records the event for 15 s.
 - (2) Stereoscopic motion sensitive CCD computerized video camera system.
Two Black & White cameras are placed 170 m apart making the system able to find bearing and distance to detected light phenomena's. This data steers a color CCD zoom video camera to take a picture to a web page.
 - (3) Vector magnetometer FMV 400.
Computer controlled and connected to internet. Monitors the earth magnetic field in three axes and displays data every hour on web.
 - (4) Weather station.
Monitors temperature, air pressure, wind speed and direction. Connected to internet.
 - (5) Radar, Raymarine 2 KW.
A 10 GHz Marine navigation RADAR system.

Italian and Norwegian researchers have since 2000 conducted field investigations in the valley through the EMBLA program. To increase visibility and probability for detection, a new program called Science Camp was started in 2002. More than 100 students, teachers and researchers have participated in this program every autumn. During this Science Camp, three mountain bases are equipped with instruments and manned for up to 14 days, see Fig. 3. One mountain base consists of two large tents, one for instruments and one used as living quarter. Each base is normally manned by 12 people, working shifts.

A head quarter is established in the valley, with radio communication to all mountain bases, and manned 24 h a day. Together with BlueBox, and the autonomous research station, 5 observation posts are in operation simultaneously, making it possible to correlate optical sightings



Fig. 3. Research base on the Rogne Mountain during Science Camp.

with instrumental data. Each mountain base is equipped with the following instrumentation:

- Mountain base equipment for Science Camp:
 - (1) Radio transceiver ICOM 50 W for VHF & UHF for communication.
 - (2) Radio transceiver 0.5 W hand held for VHF & UHF for communication.
 - (3) Geiger counter, computerized.
 - (4) INSPIRE VLF receiver & spectrometer. Loop antenna to detect magnetic field. Spectrum lab software used for analyzing the signals.
 - (5) Spectrum analyzer Rohdes & Schwartz. Scanning receiver detects electrical field in 1 KHz–3 GHz with broadband omnidirectional antenna.
 - (6) Digital SLR camera with grating. Nikon D80 with 50 mm f8 lens on tripod. Detects optical spectrum from light emitting sources. Computer controlled.
 - (7) Weather station to detect temperature, air pressure, humidity, wind speed and wind direction. Computerized with statistical analysis.
 - (8) CCD video camera on tripod.
 - (9) Spotting scope, starwatcher 500 mm f5.6 with redpoint laser sight.
 - (10) Marine binoculars 8 × 50 with inbuilt compass, used to take out bearing.
 - (11) Night vision scope with IR transmitter.
 - (12) GPS.
 - (13) Green laser 5 mW, used for checking for interaction with the phenomena.
 - (14) Toolkit for chemical analysis of bacteria growth, pH, and sulfate.
 - (15) Solar cell panels and car batteries for DC power supply.

After gaining experience with equipment and organization, the first successful Science Camp was completed in 2004, when photographs of optical spectrums from the Hessdalen phenomenon were obtained. This program has so far managed to secure data every year since then.

4. Results and discussion

Research has been going on permanently in Hessdalen since 1998 when the research container, BlueBox, was installed. This research has provided data necessary to conclude that the Hessdalen phenomenon exists and is localized to the area in and around the Hessdalen valley. The data obtained, supports the data from Strand in 1984 [4] and indicates that the frequency of occurrence varies. Research performed by Teodorani [12] based on data obtained from BlueBox during the years 1998–2001 indicates no correlation between luminous events and solar activity.

The instruments used in the period from 1998 until 2008 produced the following results:

- (1) Motion sensitive CCD computerized video camera system.

In December 1998, just a few months after the installation of BlueBox, the video camera system captured a large luminous flying object for 15 s. This attracted attention from all over the world and encouraged the research. This system has since then captured several events and works as a proof for the existence of the phenomenon.
- (2) Stereoscopic motion sensitive CCD computerized video camera system.

The very complex system collapsed in 2003 and provided no interesting data.
- (3) Vector magnetometer.

The readings indicate that the earth magnetic field rises before luminous events occur. Lack of consistent optical and radar correlation with these magnetic events can not support this indication.
- (4) Weather station.

Observations done from the mountain bases during the Science Camps, indicate that luminous events occur when air humidity rises over 85%. This increases the conductivity of the air and suggests breakdown of an electrical field created by electrical charges built up in the mountains. This breakdown has not been confirmed by any of the radio frequency receivers used in the valley. The phenomenon is not connected to thunderstorms and lightning discharges, it shows itself mostly when the sky is clear and no wind.

An outbreak of Aurora Borealis in September 2006 and 2007 happened right in front of the occurrence of the Hessdalen phenomenon. A very intense and long lasting observation, 30 min, of the phenomena in 2007, see Fig. 1, happened less than a hour after an outbreak of the Aurora Borealis.
- (5) Radar, Raymarine 2 KW at 10 GHz.

This is a marine radar used for navigation, and placed in a 12 m pole above the BlueBox with the mountain side as background. Reflections from the mountain-side tarnish the radar-screen with false echoes and ruins observations.
- (6) Night vision scope with IR transmitter.

Several first generation low resolution night vision scopes has been used during Science Camp with few

- or no results. A new digital night vision scope, Youkon Ranger LT 5 × 42, connected to a video screen was successful as a early warning device.
- (7) Radio transmitter.
A 100 and 50 W radio transmitters have been used in the valley since 2002 without any evidence of interaction with the Hessdalen Phenomena. A report from 1984 tells about a close encounter, not more than 50 m, when the phenomena disappear at the same instant as the observer triggers his radio. Observations done since 2002 can not support this hypothesis.
- (8) Laser.
In 1984 Strand [4] reported about interaction with laser. Struck by a laser beam the light phenomena started to double blink as long as the laser was pointed towards it. This happened 8 of 9 times. This experiment has not been carried out since then, due to lacking opportunities.
- (9) Geiger counter.
This device has been used extensively during Science Camp since the beginning, however with no results. Background radiation seems to be lower in the Hessdalen area than elsewhere, in average 0.1 MicroSivert. Although Fryberger's model [7] predicts radioactive radiation he warns about that the detection range is approximately not more than 150–1000 m! Such close encounters are extremely rare, but possible, and has not happened during this period. In 2004 a Light Ball was photographed when it was less than 150 m from a house. See Fig. 4.
- (10) Heat.
Several photos taken during the Science Camp show events where the phenomena touch ground or tree tops. See Fig. 4. Examinations of these areas show no sign of burning or heat. If the phenomena were emitting heat, the valley should have been haunted by fires, which is not the case. No fires have been reported in this period. Light phenomenon as big as a car seems to emit no heat.
- (11) Sound.
No sound is ever heard from the phenomena during the observations.

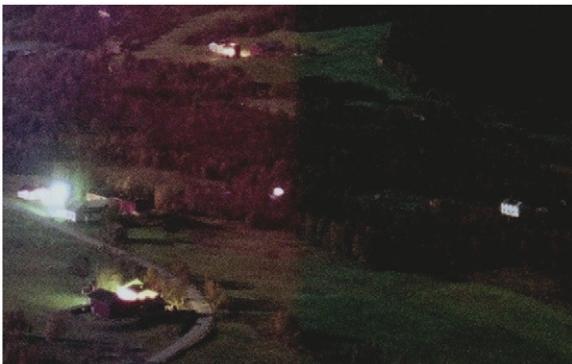


Fig. 4. Hessdalen phenomena photographed in 2004 at low altitude and close to houses.

- (12) Chemical analysis.
Samples of soils have been collected in 2007–2008 to check for growth of bacteria, pH and sulfate. Positions of samples are recorded by GPS readings. PH and sulfate analysis has so far given no conclusive results. Strand [13] reports about an event when the phenomena were seen while landing on the snow. A spiral track was left without melting the snow. Analysis made of the snow showed that most of the bacteria were killed in the landing track samples, but not in samples taken 15 m away. Two similar findings were done during a Science Camp in 2007 at Vårhuskjølen and Ingbriktsvollen where samples showed lack of bacteria. No correlation with optical observations of the phenomena landing exact there makes these data interesting, but not conclusive. More examinations have to be carried out.
- (13) Spectrum analyzer.
Different spectrum analyzers have been extensively used since 2000. This is a scanning radio frequency receiver sensitive to electric field in the range 1 KHz–3 GHz. All radio-, TV- and mobile phone-communication is monitored easily, but no signal is received that can be linked to the phenomenon.
- (14) SS-5 and SENTINEL-1 spectrometers.
These spectrometers are linked to a 1420 MHz receiver which is a frequency used for astrophysical and SETI research. Neutral hydrogen can produce radiation at this frequency due to two closely spaced energy levels in the ground state of the hydrogen atom. This transition is very rare, and only interstellar clouds in the universe contain enough hydrogen to produce a significant signal. Radio signals penetrate the atmosphere very easily on this frequency, it is regarded as a radio-window, and proposed for use in intergalactic communication. No signals of interest were obtained with this equipment.
- (15) ULFO, ultra low frequency observer.
This is a spectrometer which is connected to a correlation receiver with two magnetic loop antennas. It is extremely sensitive to magnetic fields in the 1.14 KHz range. This system has captures many interesting signals including submarine communication, but none that can be connected to the Hessdalen phenomenon. Romero and Monari conclude that the spectrograms from ULFO do not indicate any anomalous phenomenon, and that the system is being partly jammed by signals from high voltage power lines that pass near by [14]. However, this system was placed in the frontline September 2007, when the best observation since 1984 shoved up a few kilometers away as seen in Fig. 1. The phenomena moved at high speed northwards in the valley, visible for 30 min, but no magnetic signals were detected on the ULFO system. This result, no magnetic signal when moving, implies that the Hessdalen phenomenon is free of charge or that the total amount of charge is zero.
- (16) INSPIRE, interactive NASA space physics ionosphere radio experiment.

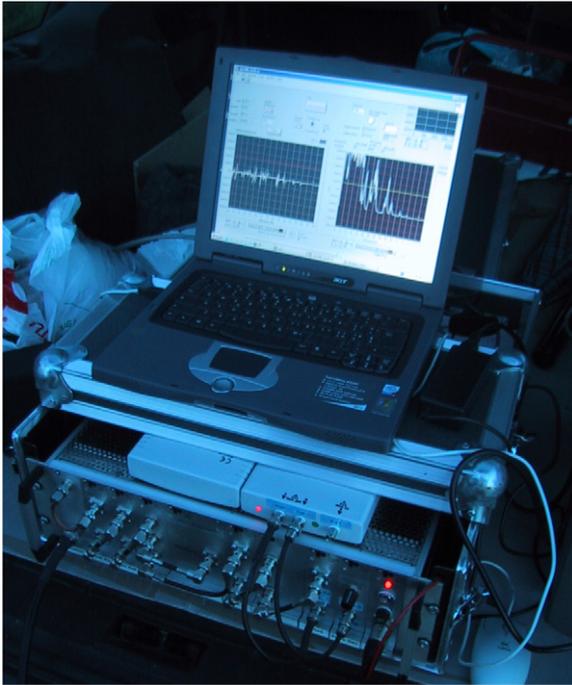


Fig. 5. UHF radar.

During Science Camp tree such systems have been operational in the valley at the same time. Using loop antennas, this system detects magnetic signals in the range 1–20 KHz. As with the ULFO system, which also uses loop antennas, no significant data has been recorded. During the 2007 event, no one reported about any anomalous signals from this system. In 2008 one receiver was equipped with a 20 m long wire antenna, detecting electric field, and properly grounded near the Øyungen Lake. This remote area is free from power line interference. This system was very sensitive and able to detect radiation from Aurora Borealis

(17) UHF low power pulsed radar.

This is a low power and low frequency radar [11], transmitting at 440 MHz, compared to 10 GHz for the navigational Raymarine system. The low frequency and thereby long wavelength is suited for studying atmospheric conditions. This system has a fixed antenna with an opening angle of 20°. All objects with a sufficient density and reflecting area will give an echo on the oscilloscope two axis screen. Vertical axis shows signal strength and horizontal axis distance. See Fig. 5.

Bearing is determined by the fixed antennas position, and all echoes inside the opening angle of 20° are displayed on the vertical axis by their different distances. This is very different from the Raymarine system where the antenna moves and both distance and bearing is shown on a circular screen. The UHF system works mainly as a range finder. The system is installed in the middle of the valley at the farm of Skogås, overlooking the

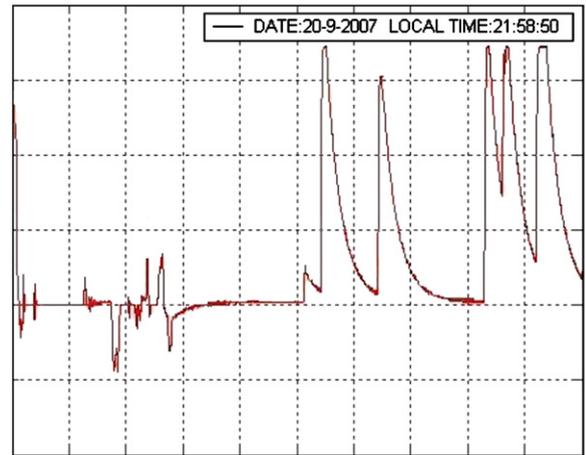


Fig. 6. Radar Echoes of the phenomena seen in Fig. 1. 20 September 2007 [17].

Skarvan mountain. Antenna bearing is 200°. In September 2007 the radar started to give echoes half an hour before the phenomena was seen optically, and went on for 3 h after. This confirms Strand's data from 1984 [4], where they observed the phenomenon on radar while it was optically invisible. This is also predicted by Zou [6] where his vortex plasma model shows a state where the temperature of the plasma is too low to emit visible light. Fig. 6 shows the UHF radar screen when the optical outburst ended in 2007. This event was confirmed by eye witnesses, video and SLR camera with grating as seen in Fig. 1.

(18) Digital SLR camera with grating.

This system works as a low-resolution spectrometer. Optical spectrums obtained in 2006 indicated a combustion process involving air and dust from the valley. Emission lines from Nitrogen, Oxygen, Iron, Silicon and Scandium were dominant in the spectrum [15]. Fig. 7 shows the intensity spectrum of the Hessdalen phenomenon. Intensity calibration has not been carried out. Noise, low resolution and vertical motion smears out and widens the lines as in Fig. 1. The spectrum looks continuous, and points towards high-density plasma or a solid object. At this point it is not possible to state whether we have a continuous spectrum or not. The resolution of this system must be improved in order to determine whether the spectrum is continuous or not.

5. Conclusion

The installation of the automated research container in 1998 and the following campaign, lasting more than a decade, has determined the existence of the Hessdalen phenomenon and its location to this area. Several findings done by Strand in 1984 [4] has been confirmed.

The phenomena have a density and reflection area large enough to reflect radar pulses. It shows itself on radar while invisible in optical band. The phenomenon's

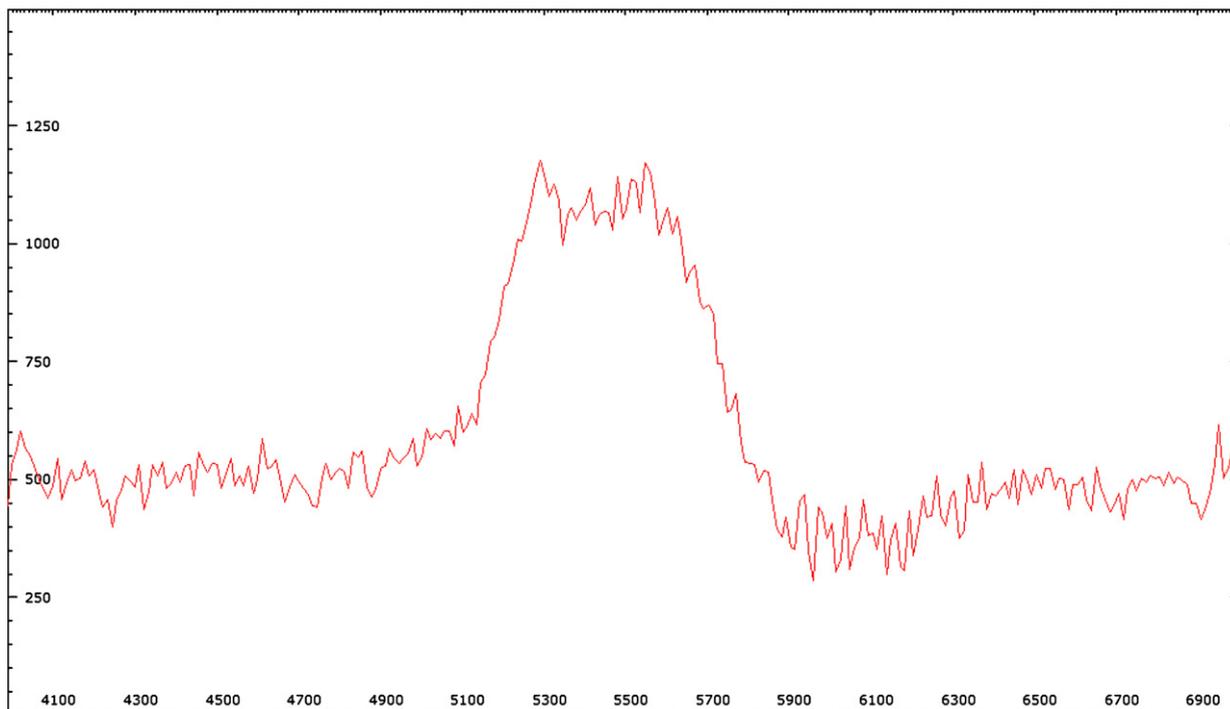


Fig. 7. Intensity plot of the optical Spectrum from the phenomena obtained in 2006.

invisible phase is explained by Zou [6] as a rotating vortex plasma model where the plasmas temperature is too low to emit light. Low temperature is supported by the fact that landing sites show no sign of burning or fire.

The phenomenon's ability to kill bacteria in the soil when touching ground, as reported by Strand in 1992 [13], is only partly confirmed and must be investigated more. No detection of radioactive radiation is done in this period, and no evidence is found to support models for internal driven energy source such as Fryberger [7]. Fryberger's own predictions warn about short detection ranges as low as 150 m, and data from Strand shows that no bacteria is killed 15 m away from a landing track, while all bacteria in the track is killed. Such bacteria free areas have been found during this period without any optical confirmation. No magnetic field has been detected while the phenomenon is active. This lack of magnetic field points towards the existence of a static electric field and that the total charge of the lightball is zero.

Reports of high humidity in front of lightball outbreaks, with increasing conductivity, may cause a static field breakdown and support this theory. The electromagnetic pulse created by a field breakdown has until now not been detected. Work done by Wessel-Berg [16] and data from 2007 must be analyzed to find the locations for static charge build up. New instruments for detecting electrical fields and charge must be implemented.

Digital SLR cameras have been a great success in obtaining low resolution spectra from the phenomena. The light ball may be created by a combustion process, involving air and dust from the valley. Evidence of continuous spectra is not fully convincing as in Fig. 1 due to the systems low

resolution and horizontal movement of the lightball. Proof of high density plasma is inconclusive. Solid matter is ruled out by the law of inertia and the absence of sound.

The power source of the phenomenon is still not found. Conclusions about External or Internal energy source cannot be done, and new data seems to produce more questions and increase the complexity.

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