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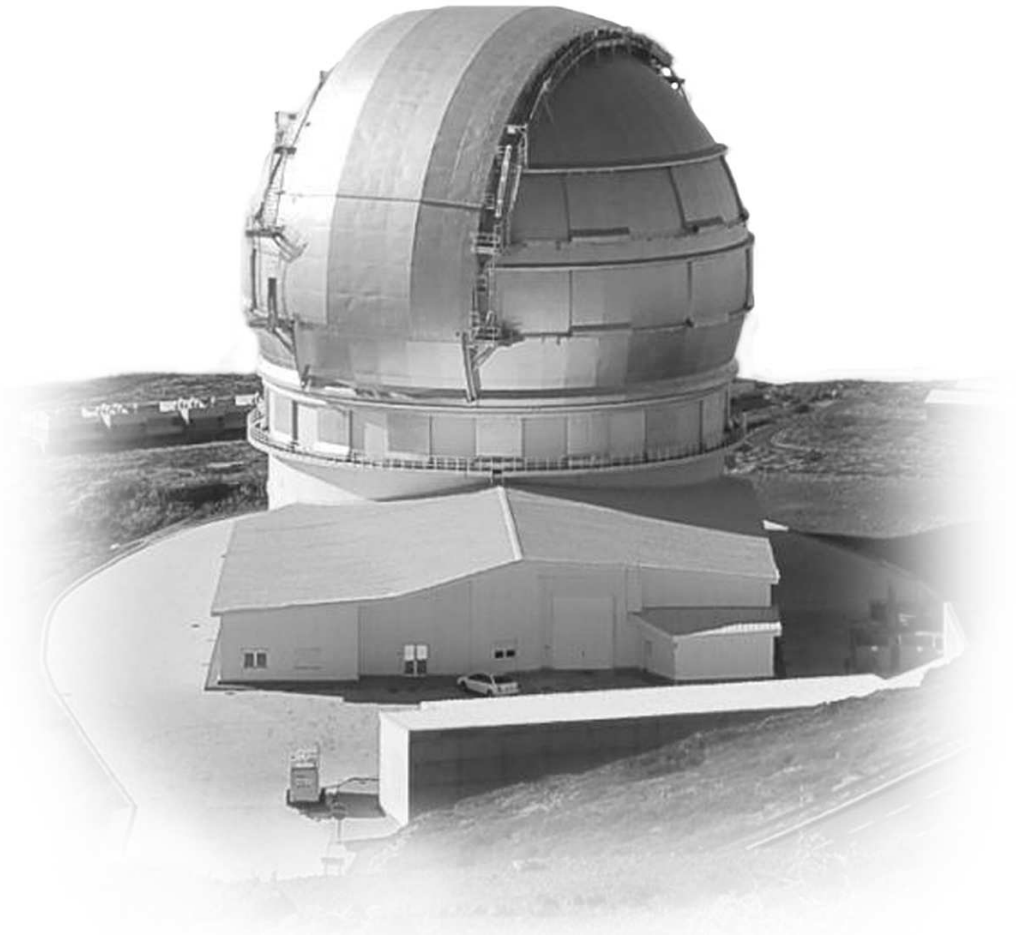

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Radio meteor scattering with Software Defined Radio based on Open Hardware

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A method is described for SDR-based meteor detection on MLAB, an Open Hardware project.

1 Introduction

The general principle of meteor observing by forward scattering of radio waves off their trails is easy to understand. It is illustrated in Figure 1. A lower VHF radio receiver (30–200 MHz) is located at a large distance (about 500–2000 km) from a transmitter at the same frequency. Direct radio contact is impossible due to the curvature of the Earth. When a meteor enters the atmosphere, its trail may reflect the radio waves from the transmitter to the receiver. At the receiver, where the signal of the transmitter is normally not received, the transmission can then be received for a moment, as long as the meteor trail is present. Such reflections can last from a tenth of a second to a few minutes. The received signal characteristics are related to physical parameters of the meteoric event.

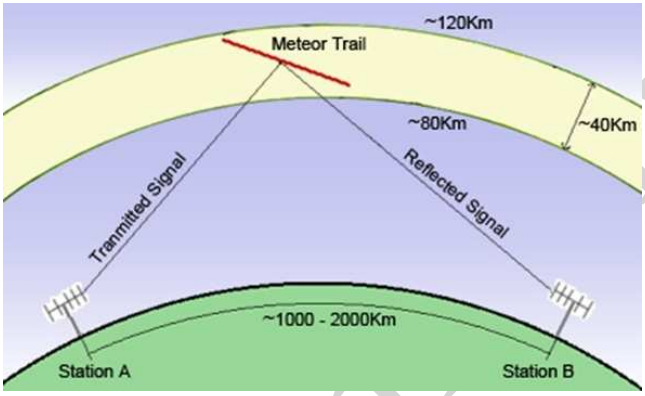


Figure 1 – General principle of meteor observing by forward scattering of radio waves off their trails.

2 GRAVES radar—Grand Réseau Adapté à la VEille Spatiale

We use the GRAVES radar for our meteor scattering experiments. The GRAVES Project (French acronym for "large-scale network adapted to spatial monitoring") offers the only means for monitoring low orbits in Europe. Its operation was handed over to the French Air Force at the time of in-service implementation in December 2005. This system was designed and built by France's Onera Aerospace Research Center under the supervision of the General Armament Delegation (DGA). With responsibility assigned to the Command and Control System for Air Operations (SCCOA), the GRAVES system offers:

1. non-stop operations, 24 hours a day, 7 days a week, without any human intervention;
2. detection of objects in orbit at an altitude of between 400 and 1000 km when flying over mainland French territory;
3. orbit pattern descriptions of all detected objects.

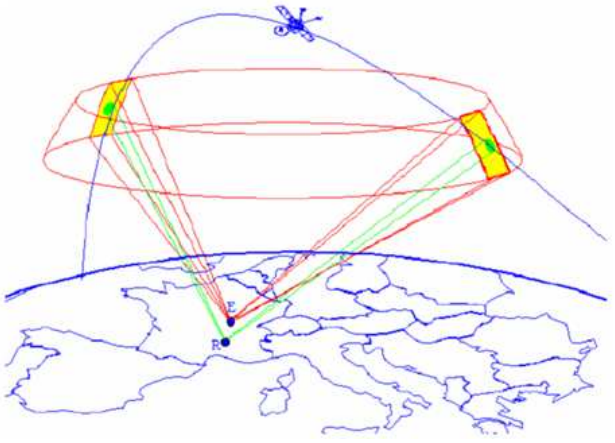


Figure 2 – The GRAVES Project.

GRAVES is a bistatic RADAR system using Doppler and directional information to derive the orbits of the detected satellites (see Figure 2).

Its operating frequency is 143.050 MHz, with the transmitter being located on a decommissioned airfield near Broye-lès-Pesmes at $\varphi = 47\,^{\circ}3480$ N and $\lambda = 5\,^{\circ}5151$ E and the receiver at a former missile site near Revest du Bion on the Plateau d'Albion at $\varphi = 44\,^{\circ}0715$ N and $\varphi = 5\,^{\circ}5346$ E (see Figure 3). Data processing and generation of satellite orbital elements is performed at the Balard Air Complex in Paris, $\varphi = 48\,^{\circ}835$ N and $\lambda = 2\,^{\circ}280$ E.

(a) Transmitter, aerial view.

(b) Receiver, aerial view.

(c) Transmitter, close-up view.

(d) Receiver, close-up view.

Figure 3 – GRAVES is a bistatic radar system.

3 Receiving meteors

We have two receiving stations, Svákov Observatory and the Slovak Central Observervatory. The location of these two Czech stations as well as of the GRAVES system is shown on Figure 4. Figure 5 shows the receiving antenna at the Svákov Observatory.

We use Software Defined Radio SDRX01B for receiving meteor trail reflections. SDRX01B is based on the MLAB Open Hardware Project. We provide all documentation for manufacturing and reviewing for free. Moreover, this hardware can be extended easily by other MLAB modules, such as processors, A/D converters, and amplifiers. Figure 6 describes the set-up. Figure 7 gives an impression of how our data looks like, and Figure 8 shows equipment of the receiving station at the Slovak Central Observatory.

Figure 4 – Google map indicating the location of the GRAVES system and the Czech receiving stations.

4 Future work

Unfortunately, the ionosphere is very complex. Elimination of the influence of the Sun is necessary for data mining of particular disturbances caused by GRBs or other distant high-energy sources. Other data sources about the solar activity have to be considered. For instance, VLF SID monitors or other data sources have to be combined with our data.

1. It is necessary to build a network of receiving stations for meteor trajectory measurements.
2. We need more precise time synchronization of the receiving stations. Currently, we cannot measure parameters of meteor trajectories. In the future, we hope to achieve this.
3. We need to compare with visual observations. We are expecting something unexpected. ☺

Comments an sources

For your comments or proposals, please contact the authors and Josef Szylar at `info@robozor.cz`. Sources:

- `http://www.mlab.cz`;
- `http://www.astrozor.cz/index.php?udalost=5`;
- `http://www.ok1dub.cz/ok0eu`;
- `http://ok0eu.fud.cz`; and
- `http://www.astrozor.cz/index.php?udalost=43`.

(a) Aerial view. (b) Close-up.

Figure 5 – Our receiving antenna at the Svákov Observatory.

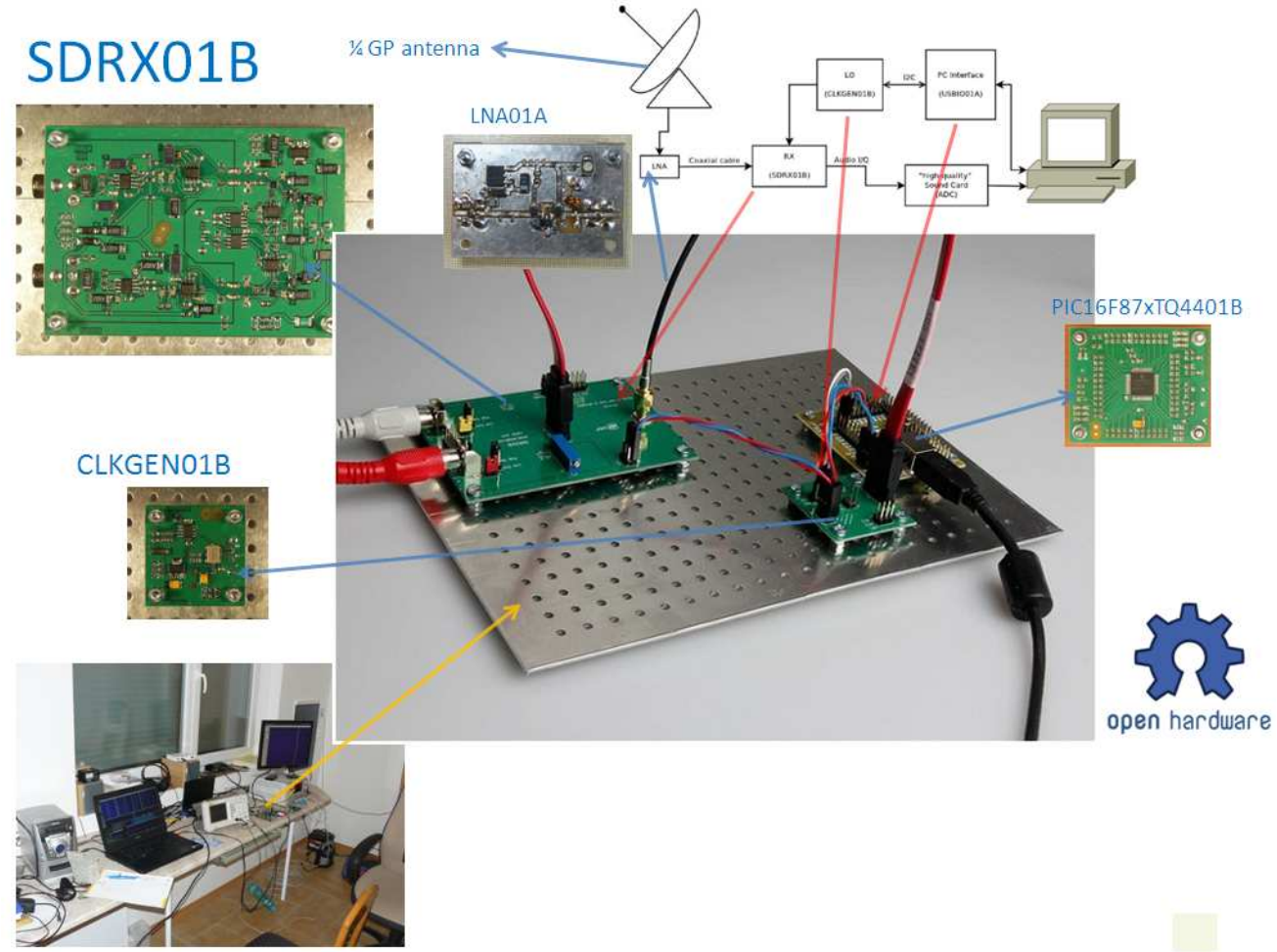


Figure 6 – Software Defined Radio SDRX01B is based on the MLAB Open Hardware Project.

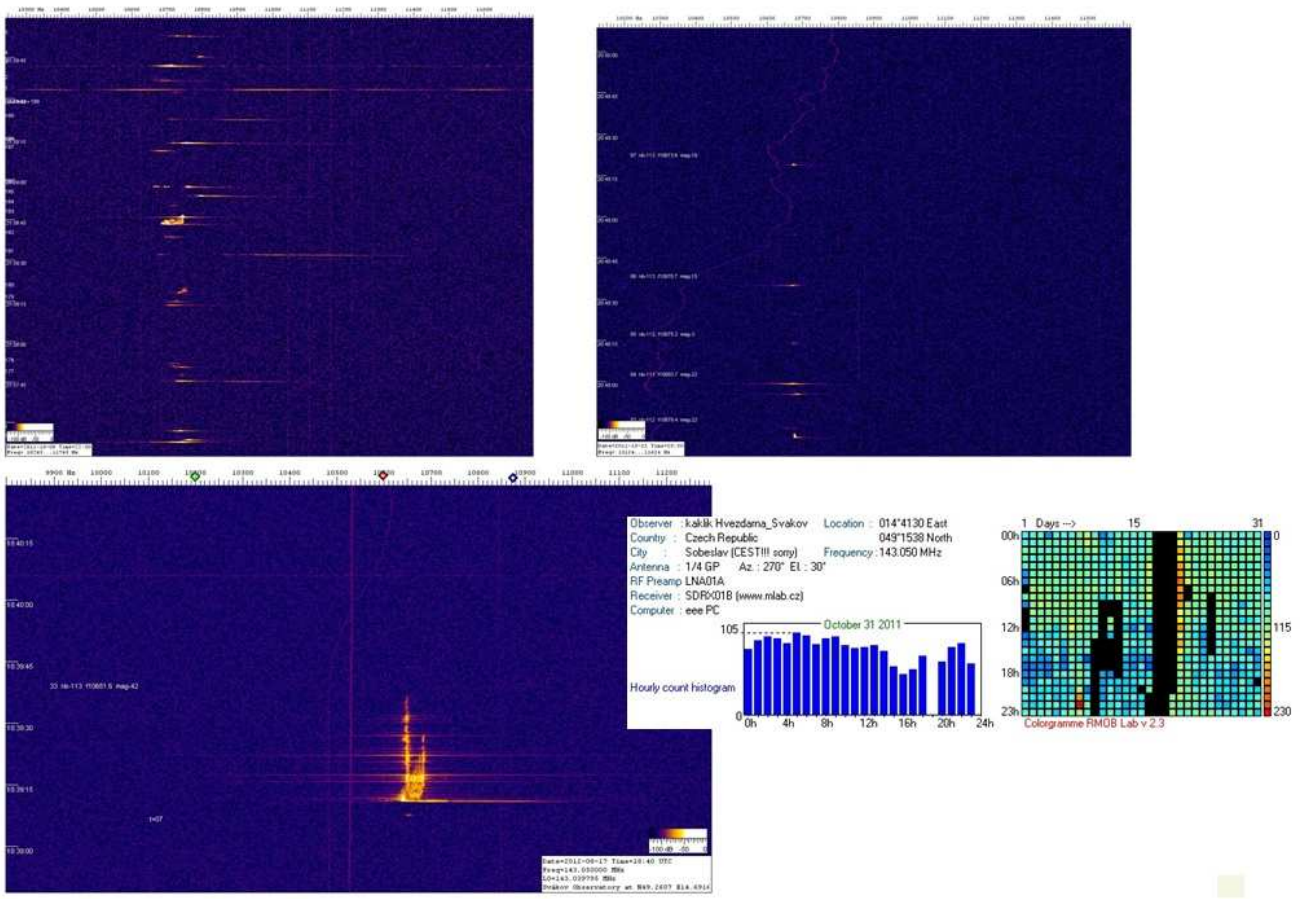


Figure 7 – Sample of our data.

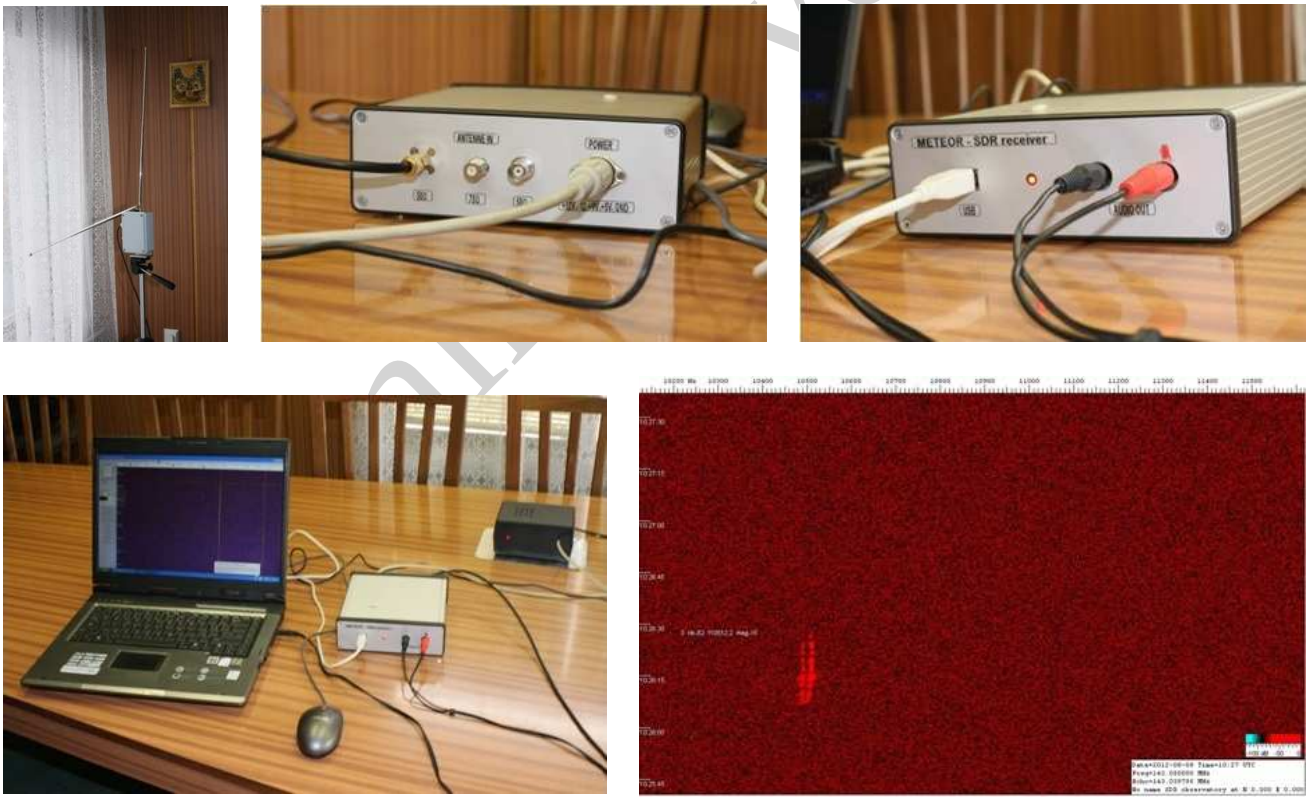
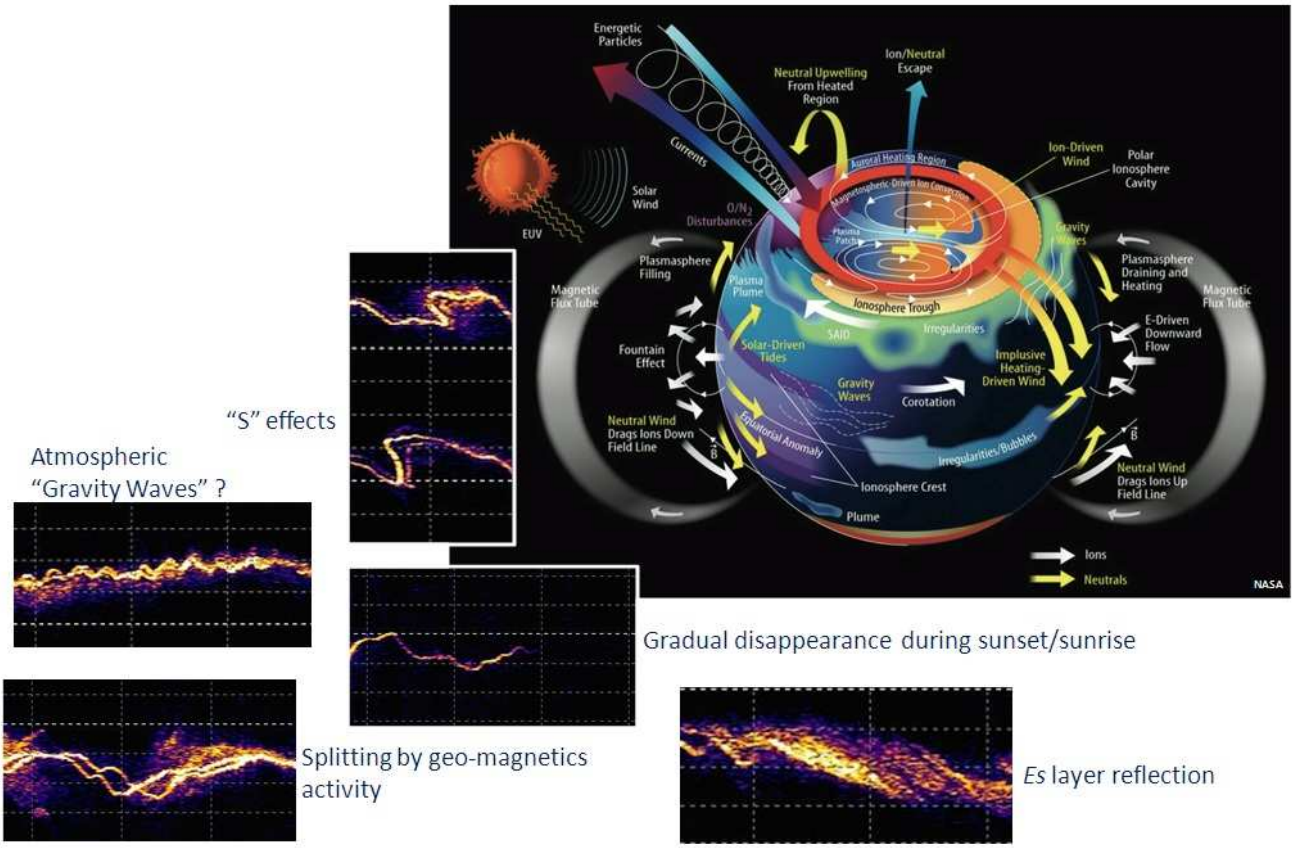


Figure 8 – Meteor receiving at the Slovak Central Observatory.



"S" effects

Atmospheric "Gravity Waves" ?

Gradual disappearance during sunset/sunrise

Splitting by geo-magnetics activity

Es layer reflection

Figure 9 – Some future plans.