Planetary and Space Science 143 (2017) 12–20

Contents lists available at ScienceDirect

Planetary and Space Science

journal homepage: www.elsevier.com/locate/pss

Current status of Polish Fireball Network

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ARTICLE INFO

Keywords:
Meteor
Meteorite
Meteoroid streams
Meteor showers
Orbits

ABSTRACT

The Polish Fireball Network (PFN) is a project to monitor regularly the sky over Poland in order to detect bright fireballs. In 2016 the PFN consisted of 36 continuously active stations with 57 sensitive analogue video cameras and 7 high resolution digital cameras. In our observations we also use spectroscopic and radio techniques. A PyFN software package for trajectory and orbit determination was developed. The PFN project is an example of successful participation of amateur astronomers who can provide valuable scientific data. The network is coordinated by astronomers from Copernicus Astronomical Centre in Warsaw, Poland. In 2011–2015 the PFN cameras recorded 214,936 meteor events. Using the PFN data and the UFOOrbit software 34,609 trajectories and orbits were calculated. In the following years we are planning intensive modernization of the PFN network including installation of dozens of new digital cameras.

1. Introduction

Since the 1930's there have been many research projects which main objective was to obtain information on the orbital elements of meteoroids entering the Earth's atmosphere (Steel, 1996). Knowing the orbital parameters of meteoroids one can study the distribution of small objects throughout the Solar System, characteristics of meteoroid streams that intersect the Earth's orbit as well as the parent bodies forming these streams (Jenniskens, 2006; Rudawska et al., 2012; Rudawska and Jenniskens, 2014). In order to calculate orbits of meteoroids a network of cameras is needed. Such a network consists of observation stations spread over a wide area, which are situated in such a way that they are able to catch an image of the same meteor. By cross-correlating results of many observations of the same meteor, it is possible to compute its atmospheric trajectory and later its heliocentric orbit and also a possible impact area of a meteorite.

The Earth's atmosphere has never been so intensely monitored before. The European Fireball Network (EN) (Oberst et al., 1998) has been the longest-running functional project with high consistency of the network functioning. Currently, several projects based on observations carried out by fireball networks operate worldwide, among others there are: European Fireball Network (EN) (Europe), Southern Ontario Meteor Network (Canada) (Weryk et al., 2008), NASA All Sky Fireball Network (USA) (Cooke and Moser, 2012), Spanish Meteor Network (Spain) (Trigo-Rodríguez et al., 2006, 2007), Desert Fireball Network (Australia) (Bland et al., 2006; Devillepoix et al., 2016), CAMS (Jenniskens et al., 2011), SonotaCo Network (Japan) (SonotaCo, 2009), the Polish Fireball Network (Poland) (Olech et al., 2006), FRIPON (Colas et al., 2014). The European viDeo MeteOr Network Database (EDMOND) (Kornos et al., 2013) collects results from many European video meteor networks. Each network has its own characteristics, and different technical potential which allows it to cover different ranges of brightness distribution of meteors. In Table 1 a selection of most important networks of cameras for observations of fireballs and meteors with their basic characteristic are summarised.

A number of networks are focused mainly on capturing small number of brightest fireballs and searching for meteorites. These systems use DSLR cameras (EN and DFN) or professional CCD cameras

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http://dx.doi.org/10.1016/j.pss.2017.03.013
Received 30 September 2016; Received in revised form 8 March 2017; Accepted 30 March 2017
Available online 31 March 2017
0032-0633/

Table 1
Selection of most important networks of cameras for observations of fireballs and meteors with their basic characteristic.

Network	Region	Methods	Main interest
European fireball network (EN)	Central Europe	Photographic: all sky analogue and DSLR	Fireballs
Spanish Meteor Network (SPMN)	Spain	Photographic: all sky CCD	Fireballs
Desert Fireball Network (DFN)	Australia	Photographic: all sky DSLR	Fireballs
Fireball Recovery and InterPlanetary Observation Network (FRIPON)	France	Video: all sky digital cameras	Fireballs
All-Sky Meteor Orbit System (AMOS)	World Wide: (Slovakia, Canary Islands, Chile)	Video: intensified all sky digital cameras	From fireballs to faint meteors.
Southern Ontario Meteor Network	Canada	Video: from all sky to intensified narrow field of view analogue and digital cameras.	From fireballs to faint meteors.
NASA Fireball Network	USA	Video: all sky analogue cameras.	Fireballs
Cameras for Allsky Meteor Surveillance (CAMS)	World Wide: (USA, New Zeland, BeNeLux, UAE)	Video: narrow field of view analogue cameras.	From fireballs to faint meteors.
SonotaCo Network	Japan	Video: narrow field of view analogue and digital cameras	From fireballs to faint meteors.
Polish Fireball Network (PFN)	Poland	Photographic: DSLR Video: narrow field of view analogue and digital cameras	From fireballs to faint meteors.

(SPMN) with fish eye lenses. Due to high resolution of cameras it is possible to achieve an estimation of trajectory with uncertainty up to 10 m. To reduce high costs of the system the FRIPON is using digital video cameras with much smaller resolution than DSLR cameras. The low cost allows them to create a network based on 100 stations covering the whole surface of France. Currently this network is still being constructed. Constraints of limiting magnitude of the all-sky system have been overcome by the project AMOS through the use of the expensive image intensifiers. In order to cover the whole sky while maintaining high resolution and a good limiting magnitude CAMS system is based on stations with several sensitive analogue cameras with narrow field of view, which makes it possible to record a large number of faint meteors. A more economic version of this solution is a network with analogue cameras and wide angle lenses. These types of networks are created mainly by amateurs because of the low cost of the equipment. The PFN was one of the first networks that proposed such a solution (Olech et al., 2006). A year after the PFN, the SonotaCo network started its operation following the same method. The main advantage of the PFN model, compared to other solutions, is a simultaneous use of several devices like low cost wide field analogue cameras, expensive sensitive narrow field analogue cameras, wide field digital cameras and all sky DSLR cameras to observe all events, from fireballs to faint meteors.

2. Methods of observations and data reduction

2.1. Structure of the Polish Fireball Network

The Polish Fireball Network (PFN) is a project whose main goal is to monitor regularly the sky over Poland in order to detect bright fireballs occurring over the whole territory of the country (Olech et al., 2006, Żołądek et al., 2009, Wiśniewski et al., 2012; Wiśniewski and Żołądek, 2015). The project is an example of successful participation of amateur astronomers who are able to provide valuable scientific data. Most of the PFN observers are amateurs, members of the Comets and Meteors Workshop who often have purchased equipment with their own funds or use cameras belonging to the PFN. They perform observations as a part of their astronomical club, school activities or on their own, at home. The PFN is coordinated by astronomers from Copernicus Astronomical Centre in Warsaw, Poland.

2.2. Observations

The PFN observe the sky using video and photographic techniques. In 2016 the PFN consisted of 36 continuously working stations with 57 video and 7 digital cameras. The stations are able to work all year round. Camera housing provides protection from rain, snow and low temperatures. Some stations can be found in the centres of large cities. Some stations are remotely controlled via the Internet, and require only periodic inspection. Detailed information about the Polish Fireball Network stations presents Table 2.

2.3. Analogue video observations

The PFN mainly uses sensitive video cameras from Mintron, Watec, Tayama and Siemens. In order to find the best instruments for astronomical observations a big test of CCTV industrial cameras have been conducted. The results of that test were described in Wiśniewski et al. (2005). The best price/quality ratio is offered by sets of Tayama C3102-01A1, Mintron MTV-23X11C and Siemens CCBB1320-MC cameras with 1/3 in. detectors with a standard PAL resolution of 768×576 pixels, equipped with CS mount Ernitec or Computar f/1.2 4 mm lenses. A Tamron and Computar zoom f/1.0 3–8 mm lenses fixed at focal length of 4 mm are used too. Such a set features a field of view of about 62×48 degrees and the limiting magnitude for meteors down to $+2$ mag. The pixel size for these cameras is about 5′. Some of the PFN stations are equipped with most sensitive analogue cameras such as Mintron 12V6HC-EX and Watec WAT-902H2 Ultimate with 1/2 in. detectors and lenses as fast as f/0.8 and focal length ranging from 3.8 mm up to 12 mm. With the help of these cameras we collect data for large number of faint meteors down to $+5$ mag (Wiśniewski et al., 2015). The camera systems are sheltered in weatherproof and heated housings.

The MetRec software written by Sirko Molau (1999) and UFOCapture written by SonotaCo (2009) are used in the process of meteor detection. The meteor detection in video signal is automatic. After the observation period camera operators are able to eliminate phenomena that are not meteors, for example: birds, insects, aircrafts or fast-moving clouds. Cleaned data are sent to the coordinator of video observations for final data analysis.

2.4. Digital HD cameras for a meteor patrol

Signal from analogue cameras has its limitations and its transformation might affect image quality and final results. First, the image from CCD chip is converted into an analogue signal that is sensitive to external interference. Then the signal is transmitted to a video grabber for digitalization and reproduction of the captured image. The measurement uncertainty of brightness and position of objects depends on the quality of used components and the noise introduced during signal transmission. An interlaced image based on the reading and transmitting only every second line of the image is another factor which affects