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Meteor activities within the BigSkyEarth COST Action: enabling new approaches in modeling and observations

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Abstract

Technological advancements in observing techniques in meteor science are changing quality of research in meteor science. This includes new meteor detection strategies, as well as more reliable simulations of studied meteors. In this contribution we provide an information on some new techniques for observation and simulation of meteors that comes from the cooperation in COST Action BigSkyEarth.

1. Introduction

BigSkyEarth COST Action focuses on building a transdisciplinary network of researchers from area of astrophysics, geophysics, planetary science, and computer science (currently includes cooperation of people from more than 30 countries), with the main ambition to support their collaboration in the new era of Big Data processing of data coming from new measurements and detection sites. BigSkyEarth networking tools represent an excellent platform for discussion on improvements and collaborations in order to develop novel approaches and techniques. The cooperation of scientists in BigSkyEarth emergently created a group of researchers focused on meteor science, which were able to bring new ideas for simulation and observation of meteors, some of them are described in the next chapter.

2. Novel methods and techniques

In this section we shortly describe selected cases of novel techniques related to observation and simulation of meteors, which emerged thanks to cooperation of scientists in BigSkyEarth.

2.1 Detection of meteors from orbit and stratosphere

Within the framework of the JEM-EUSO mission project and its precursors, including the Mini-Euso mission scheduled for launch in 2019, studies are being carried out for the observation of bright meteors from ISS [3]. This can constitute a useful synergy with the activities of several networks of ground-based observers. Moreover, in this case the motion of the ISS can be used to reconstruct 3-D trajectory of meteors and fireballs in some cases. The possibility to detect some classes of WIMP particles, expected to produce signals similar to very fast meteors, is also analyzed. There are also cooperative activities within BigSkyEarth in order to put meteor detection cameras on the top of a new generation of rigid airships, which are developed by Hipersphera (https://hipersfera.hr/). This attempt would lead to the improvement of the observing conditions due to a higher altitude and changes in the observing location.

2.2 Detection of meteors in sky surveys

Another interesting method for detection of meteors came from the analysis of images collected by large sky surveys, where large fields of view is combined with a high-resolution imaging. This turns to be a unique way for exploring meteor science, where the meteor head is resolved (albeit defocused). BigSkyEarth supported this research on SDSS images [1][2]. First results showed that it is possible to extract significant number of meteors from such surveys due to their large total observing time and sky coverage. Therefore, this new initiative is also studied for the upcoming LSST survey.

2.3 Improved interpretation of meteor's parameters

To reliably interpret large amount of observational data generated by the fireball networks worldwide an attention is given to develop and implement new approaches which adequately account for the actual atmospheric conditions at the concurrent location and heights of a meteor. In [5] authors have recently proposed to tackle this problem by introducing atmospheric corrections into the previously developed model [4]. This approach can be inferred to produce more reliable estimates of the meteor′s characteristic parameters since it uses an improved representation of the atmospheric density. When applied to large data sets, the NRLMSISE-00 empirical atmosphere model [6] can be employed to provide more reliable results. Deeply penetrating fireballs, or other meteor events of special interest, could be further analyzed in more detail on a case-by-case basis using the actual measurements of the pressure profile with height. These data come from the Global Forecast System (GFS) and from the European Centre for Medium-Range Weather Forecasts (ECMWF). In practice, these atmospheric corrections have already aided rapid recovery of the Annama meteorite based on observations by the Finnish Fireball Network.

2.4 Improved understanding of meteor radar reflections

Novel numerical methods are being used to test how the changes in the atmospheric conditions or shape or size of the meteor affect its radar reflections and to explain unexpected features in the measurements. The geometry of the meteor is presented as a rigid obstacle covered by non-magnetized plasma that is modeled as a Gaussian density distribution [7]. The computational model is based on partial differential equations of multiphysical wave equations. To save computing time, the computational domain is truncated by artificial absorbing boundaries or perfectly matched layers and discretized by a three-dimensional nonuniform computational mesh. Instead of a conventional numerical discretization method, the mathematical structures are presented as differential forms and discretized by discrete exterior calculus, which together with explicit time-stepping leads to more efficient simulations than the ones available in today's commercial software products or open-source libraries.

2.5 Monitoring of the ELF/VLF/LF waves

Another interesting new solution is implemented for tracking of alert events, which is combined with meteor detection alerts from the fireball network. In this case, AWESOME (The Atmospheric Weather Electromagnetic System for Observation, Modeling, and Education receiver) represents dedicated observation instrument for monitoring of the broadband ELF/VLF/LF waves, which consists of two magnetic antennas collecting approximately 32 GB of broadband data per day.

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