Quantitative Assessment of the Effect of Group Meteors on Spacecraft by Using a Radar and an Optical Sensor

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1 Background and Objectives

Meteor is an ionization event which occurs when a tiny interplanet mass enters earth’s atmosphere. While it has a long history of research, it recently attract great attention as a possible hazard in space. In order to assess the possible impacts of meteors with spacecraft, it is essential to establish an accurate statistics of their mass and velocity. We developed a radar-optical combined system for detecting faint meteors consisting of a powerful VHF Doppler radar and an ICCD video camera.

2 Instruments and Techniques

The MU radar is a pulse Doppler radar operating at 46.5MHz, and is equipped with an active phased array antenna of 100 m size and 1 MW peak output power. The Doppler pulse compression scheme is developed to enhance the S/N ratio of the radar echoes with very large Doppler shifts, as well as to determine their range with a resolution of 200 m. Mono-pulse interferometry is introduced to determine instantaneous locations of very fast meteors. We also developed a high-sensitive video camera system with an image intensified CCD (ICCD) for simultaneous meteor observations with the MU radar. The combined radar-optical system is used to simultaneously observe faint meteors, and to estimate their mass.

3 Major Results

A very high sensitivity of more than 14 magnitude and 9 magnitude for radar and optical sensors, respectively, has been obtained. Instantaneous direction of meteor body observed by the radar is determined with the interferometry technique. We examined the optimum way of the receiving antenna arrangements, and also of the signal processing. Its absolute accuracy was confirmed by the optical observations with background stars as a reference. Fig. 1 shows the velocity distribution, which indicates a significant extension over the maximum velocity of 72 km/sec inside the solar system, suggesting the detection of interstellar dusts.

Fig. 2 shows the relation between the radar backscattering cross section and the intensity of the optical emission. By combining the impinging velocity of meteor bodies derived by the radar with the absolute visual magnitude determined by the video camera simultaneously, the mass of each meteor body was estimated. The developed observation system will be used to create a valuable data base of the mass and velocity information of faint meteors, on which very little is known so far. The data base is expected to play a vital role in our understanding of the space environment needed for designing large space structures.
Figure 1: Velocity distribution of the meteors observed by the MU radar.

Figure 2: Relation between the peak echo power and the absolute visual magnitude.

4 Significance for Space Experiments

The current study does not aim to directly utilize the space environment, but to assess the possible impact of meteors on the space environments via ground-based observations. The obtained results by the developed technique will be, however, used as a valuable data base for designing all spacecraft including the space station project. It is therefore has direct use in future space experiments.

5 Publication List


