Meteors on other planets

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Introduction

Meteors are for obvious reasons mainly investigated in the Earth's atmosphere, and this science is useful for many reasons, including the study of extraterrestrial material, comets, asteroids, celestial mechanics, atmospheric science, and physics of (re)entry. This report will review attempts and observations of meteors performed on other planets. We focus on Mars, Venus and Jupiter. We also propose a list of investigations to study meteors on other planets.

The Mars case

To illustrate the difficulty of detecting meteors on other planets, let us mention the putative detection in a panoramic camera image taken by the Spirit rover [1]. One image was showing an anomalously bright streak, that may have been a meteor trail, as the study of its light curve suggested [2]. Unfortunately, an analysis done two years later indicated that this was more likely a grazing cosmic ray impact, which we show to be a major source of confusion with potential meteors in all Pancam images [3]. More recently, in October 2014, attempts were made to detect a meteor shower during the encounter of Mars with the Siding Spring comet, with the HRSC camera aboard Mars Express. Unfortunately there were unsuccessful, despite optimistic predictions [4], confirming the difficulty of such observations on other planets. Nevertheless, indirect impacts of the Siding Spring meteor shower on the Mars' ionosphere have been identified. A major effect was the deposition of metallic species in the upper atmosphere and the associated strong increase in ionization. Measurements by different instruments onboard the three spacecraft Mars Reconnaissance Orbiter, Mars Express and Maven have provided a complementary view: The SHARAD radar recorded high values of the Total Electron Content on the nightside [5], while the MARSIS radar detected a strong ionospheric layer just below 100 km altitude, consistent with the ablation of dust particles in the atmosphere [6]. These observations were complemented by the MAVEN data, in which metallic ions such as Mg^+ and Fe^+ were identified for the first time in the Mars' atmosphere, both from the ion mass spectrometer and the UV spectrometer [7,8]. These ionospheric effects were predicted in 2003 [9] and later identified in radio-occultation data [10].

The Venus case

At Venus, effects of meteors in the ionosphere, like on Mars, have been detected by Venus Express [11]. An interesting event was reported in 1993 by Huestis and Slanger [12]. They analysed Pioneer Venus Orbiter ultraviolet data, and published spectra of NO on the nightside atmosphere of Venus. The authors outlined the detection of consecutive intense spectra, which suggests the presence of a long, straight and narrow track of secondary NO excitation, possibly caused by a meteor.

The Jupiter case

With its size and large gravity, Jupiter is an interesting target for observing meteors. Bolides of 5-20 m diameter were observed by amateur astronomers in Jupiter's atmosphere in 2010 and 2012 [13,14]. Several collisions of this size may happen on Jupiter on a yearly basis. A systematic study of the impact rate and size of these bolides can enable an empirical determination of the flux of meteoroids in Jupiter with implications for the populations of small bodies in the outer solar system. As on Mars and Venus, an ionospheric layer meteoritic in origin has also been detected at Jupiter [15].

Future opportunities

This talk will also discuss various techniques and instruments to be used for detecting meteors and/or related ionospheric effects, on other planets. Those could fly on planetary missions, or being developed for possible future applications. These includes: wide angle cameras [16,17], spectroscopy, infrasonic wave detection [18,19], radar (wave reflection and attenuation [20]), and ionosonde.

References

[1] Bell et al., Science, 305, 2004
[2] Selsis, F. et al.., Nature, 435, 2005.
[3] Domokos et al., Icarus, 2007
[4] Vaubaillon, J. et al., MNRAS, 2014
[5] Restano et al., GRL, 2015
[6] Gurnett et al., GRL, 2015
[7] Benna et al., GRL, 2015
[8]Schneider et al., GRL, 2015
[9] Molina-Cuberos et al., PSS, 2003
[10] Paetzold et al, Science, 2005
[11] Paetzold et al., GRL, 2007
[12] Huestis, D. and Slanger, T., J. Geophys. Res., 1993
[13] Hueso, R. et al., The Astrophysical Journal Letters,2010.
[14] Hueso, R. et al., Astronomy & Astrophysics, 2013
[15] Molina-Cuberos. G. et al., Space Sci Rev, 2008.
[16] Bouquet et al., PSS, 2014
[17] Christou et al., Planetary and Space Science, 2007
[18] Pilger et al., GRL, 2015
[19] Revelle, JGR, 1976
[20] Witasse et al., GRL, 2001