Meteors on other planets

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<table>
<thead>
<tr>
<th>Why studying meteors on other planet?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempts and observations at Mars, Venus and Jupiter</td>
</tr>
<tr>
<td>Possible investigations in future missions</td>
</tr>
</tbody>
</table>
Why studying meteors on other planet?

- Tests knowledge/models/predictions to other conditions
- Dust fluxes and properties elsewhere in the solar system
- Information about planetary atmospheres
Mars
Attempts at Mars

Images and light curve from the Panoramic Camera, Spirit Rover

Bell et al., 2004

Selsis et al., 2005

→ Timing, orientation and shape consistent with a meteor shower associated with comet Wiseman–Skiff.

→ First martian meteor?
Attempts at Mars

Domokos et al., 2007

→ 350+ rover images analysed
→ no conclusive meteor detections
→ the 2005 claim is more likely a grazing cosmic ray impact
Attempts at Mars

Encounter with the Siding Spring comet, October 2014.
Closest approach $\sim 130,000$ km
Relative velocity $\sim 56$ km/s

Moorhead et al. (2014), Vaubaillon et al. (2014a) $\rightarrow$ Cometary dust in the Mars’ atmosphere
$\rightarrow$ Prediction of a strong meteor shower (hurricane)
$\rightarrow$ Concerns for spacecraft safety
Attempts at Mars

SidingSpring-To-Mars Range
Range (km): 204746
Attempts with Mars Express

**Nadir**
- Incidence angle: 48°
- Meteor length: 465 pixel (~60 km)
- Duration: 1.1 s

**Off-nadir**
- Incidence angle: 66°
- Meteor length: 658 pixel (~95 km)
- Duration: 1.7 s

SRC frame, example from distance: 10,500 km
Meteor speeds: ~ 56 km/s
Beginning height: 90 km
End height: 50 km

Duration of Meteor: ~ 1.5 s, i.e., meteor may be seen in 2-3 consecutive SRC frames
Attempts at Mars

No meteor shower detected.

Farnocchia et al. (2014), Tricarico et al. (2014), Vaubaillon et al. (2014b)
→ smaller nucleus, less dust ejection
→ no meteor shower are expected

→ Forecast made too early?
→ Context of spacecraft safety...

Complex science!
Atmospheric experiments on Mars have attempted to detect meteoric showers, but despite meteor showers being numerous on Earth, no such shower has been detected on Mars. However, studies have revealed that dust ablation processes in the upper atmosphere of Mars lead to the formation of iron and magnesium-rich metals and neutral-ion chemistry. These processes are enhanced by UV photoionisation, resulting in a meteoric layer in the ionosphere.
Siding Spring observations

- Mars Express Ionospheric Radar
- Enhanced Ionization Layer Due to Dust Impacts
- Plasma Frequency
- Mars Ionosphere
- Altitude (km)

Plasma Frequency/Ionospheric Density
Siding Spring observations

- Orbit 13710
- Predicted Dust Impact Region
- Tricarico et al. [2014]
- Sub-radiant Point
- P1
- P2 Periapsis
- Terminator
- Dayside
- Nightside

Local Time (hours) vs Latitude (degrees)
Siding Spring observations

Gurnett et al., 2015
Siding Spring observations

Gurnett et al., 2015
Siding Spring observations

MAVEN/IUVS Spectrum of Mars Atmosphere After Comet Siding Spring

Meteor Shower Metal Emissions
Siding Spring observations

Geographic representation is conceptual. Atmosphere not drawn to scale.

200 km
Siding Spring observations

Eight different metal ions from comet Siding Spring were detected by NGIMS.
Venus
Venus Express observations

Meteoritic layer due to dust

Paetzold et al. (2009)
Pioneer Venus observations

Huestis and Slanger (1993)

- Observations of the Venus nightglow in the UV range
- Nitric Oxide emissions: $N + O \rightarrow NO^*$
- Three correlated bright spectra observed on a particular orbit
- Interpretation: emitting area with dimensions on the order of 900 km in length and less than 5 km in width.
- Detection of a trail of a grazing meteor
Huestis and Slanger (1993)
Jupiter
Jupiter observations

Hueso et al., 2013
Jupiter observations
→ **Size ~ 10-20 m**
→ **Estimated impact rate : 10–60 per year**

Hueso et al., 2013
Future observations?
Future observations?

- Develop hardware for future flight opportunities?
  - Wide angle cameras / spectroscopy
  - Surface ionosonde (Mars)
  - Infrasonic wave detection (Mars)
  - Radar (?)

- Nanosatellites

- (Permanent) station(s) on the martian moons
A permanent station on Phobos (Deimos)
Mars:
- No meteors detected so far (?)
- Study Siding Spring comet effects in more details: promising
- Link ionospheric effects -- dust population: to be studied

Venus:
- One meteor trail detected (?)

Jupiter:
- Good place to observe bolides. "amateur" work