Polarized emission from space particles in the Earth's upper atmosphere

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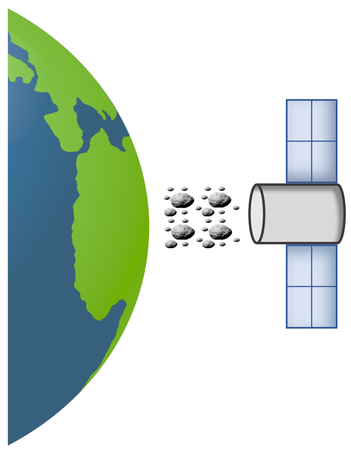
Context

Tons of **space particles enter the Earth's atmosphere** every year [1]. Most of these particles are leftovers and debris from comets and shattered asteroids. The estimates of this extraterrestrial material influx rely upon the measurements carried out by the networks monitoring short-duration fireball events and meteor showers, and by some spatially limited ground-based meteorite searches. Unfortunately, a **global space-based survey** is still missing.

Space dust in the Earth's upper atmosphere is expected to be aligned by radiative torques (RATs) [2]. This grain alignment will produce **linearly polarized thermal emission**.



Objectives

Detection of these infalling particles using **satellites in low Earth orbit**:

- We study the **grain alignment** mechanisms in the **Earth's atmosphere**.

- We compute for the **first time the expected microwave signal** of these aligned infalling particles and its polarization.

Infalling dust model

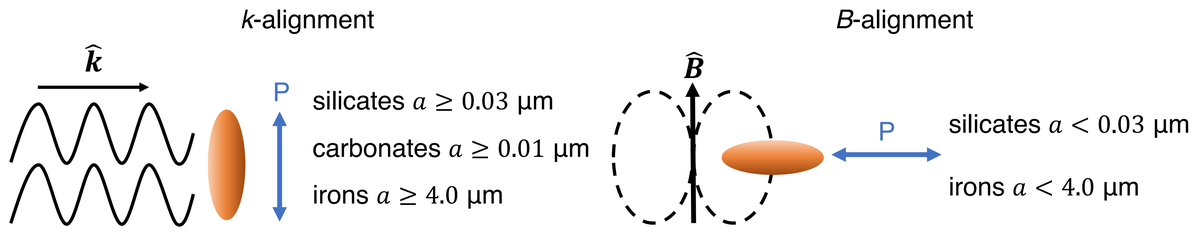
Particle properties

Little is known about the particle properties in the upper layers of the Earth's atmosphere. We retrieve the following information from found meteoritic dust, from measurements of meteor showers and from comet observations by several space missions.

- Material: amorphous silicate, carbonate and iron.
- Size: grain radius ranging from 0.01 μm to 1 cm with a size distribution described by a power law with an index α from -2.0 to -3.5.
- Spatial density: constant number density from 130 to 500 km altitude from Earth surface of 0.22 cm^{-3} in the considered range size.

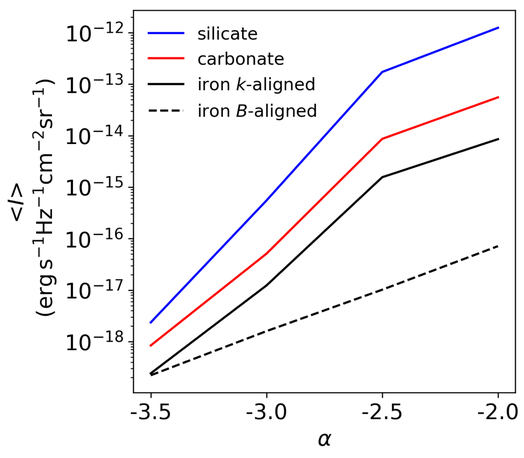
Grain alignment

Any alignment is **lost below 130 km** by collisions with the dense atmospheric gas **[3]**. Depending on the dust properties and the environmental conditions, the axis of alignment will be the direction of the solar radiation field (*k*-alignment) or the direction of the Earth's magnetic field (*B*-alignment).

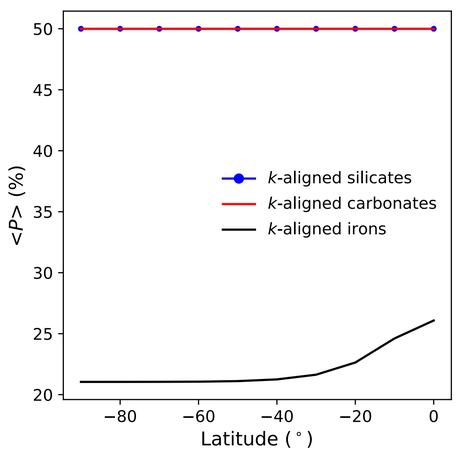


Results

For the numerical simulations, we use the Monte Carlo code RADMC-3D [4]. The falling particles are represented as a 3-dimensional Cartesian grid filled with the described material properties. The dust cloud is illuminated by the solar radiation field. We obtain the expected **thermal emission** at microwave frequencies and its **linear polarization**.

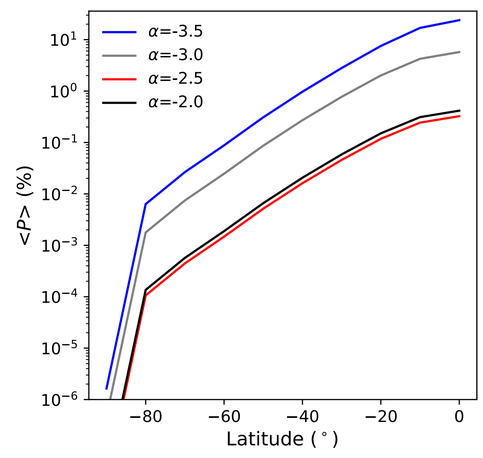


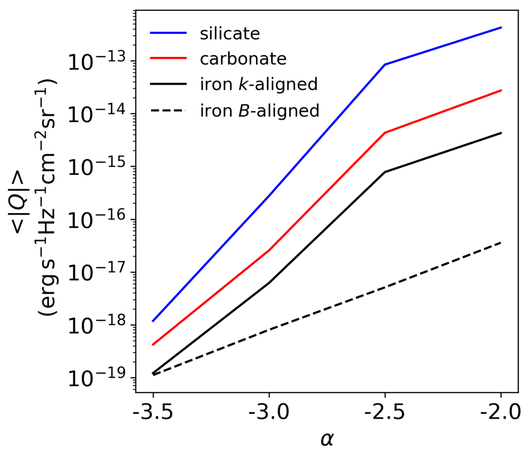
Thermal emission at 220 GHz as viewed from a satellite located at the equator at 500 km from the Earth surface.



$\alpha = -3.5$

Linear polarization of *k*-aligned grains along the satellite orbit.

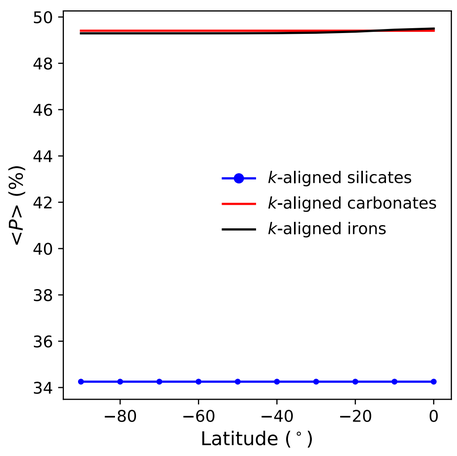




Absolute value of *Q*-Stokes parameter at 220 GHz as viewed from a satellite located at the equator at 500 km from the Earth surface.

$Q < 0$ *k*-alignment

$Q > 0$ *B*-alignment



$\alpha = -2.0$

Linear polarization of *k*-aligned grains along the satellite orbit.

Linear polarization of *B*-aligned irons along the satellite orbit.

B-aligned iron polarization shows an specific behaviour along the orbit: from minimum at South pole to maximum at the equator.

Conclusions

- We have built a grid of models that covers the several properties that infalling particles onto the Earth could have.
- In the Earth's upper atmosphere, the majority of silicates and carbonates are *k*-aligned; irons are both *k* and *B*-aligned.
- The expected simulated signal could be used as the baseline for future space missions.
- Polarization curves reveal dust properties.
- Earth observation is a rich source of information about near-Earth bodies.

References

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