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Size of dust particles derived from the photometric observations for the coma of comet 67P

Johannes Markkanen and Jessica Agarwal
Max Planck Institute for Solar System Research (markkanen@mps.mpg.de)

Abstract

We use visible (VIS), near (NIR) and thermal infrared (TIR) photometric observations to retrieve the particle size distribution for the coma of comet 67P/Churyumov-Gerasimenko. The retrieval is based on synoptic numerical modelling of light scattering and thermal emission. The modelling results suggest that the observed scattering and thermal emission features are dominated by large particles in the coma.

1. Introduction

Remotely observed scattered solar and thermally emitted radiation from the coma of a comet can be used to estimate the particle size distribution in the coma. The estimation procedure requires solving an inverse problem for Maxwell equations. Unfortunately, the solution for such a problem is not unique. Consequently, the retrieved physical parameters may be unreliable. To improve the reliability of the retrievals, the same physical model need to be used to explain observations over a wide wavelength range, e.g., from ultraviolet to infrared in which case many physical processes on different scales contribute to the received signal.

Recently, we have developed a synoptic numerical method for scattering and thermal emission. The method is self-consistent, i.e., it uses the same particle model, same physics and same numerical algorithms for each wavelength. We use this model to explain the scattering and thermal emission properties of the coma of comet 67P measured by the OSIRIS and VIRTIS instruments onboard the Rosetta spacecraft, and the ground-based infrared observations. The modelling results are used to constrain the dust particle size distribution in the coma.

2. Numerical method

We assume that particles in the coma do not contain any volatiles hence the phase changes, (sublimation and recondensation) do not contribute to the energy budget. Also, we neglect heat transport by convection, i.e., the particles are assumed to be in vacuum. Thus, we only consider conductive and radiative heat transport.

We apply the finite-element method to solve the Fourier transport equation for heat conduction in which the radiative heat transfer component is completely decoupled and introduced as a source term. This allows us to use the recently introduced dense media radiative transfer formalism [1, 2] to compute scattered, absorbed and emitted power for each wavelength.

3. Coma model

Particles in the coma are assumed to be in each other's far zone, and the coma is assumed to be optically thin. Therefore, to model scattering and emission characteristics of the coma, we can average single scattering properties over an ensemble of particles. As for the particle model, we use irregularly-shaped agglomerates of spherical submicrometer-sized carbon and micrometer-sized silicate grains. Such a particle model succeeded to explain the visible phase function of the coma of comet 67P [2].

4. Preliminary Results

Our preliminary numerical results show that if the coma do not contain a significant amount of small particles (radius $< 10\,\mu m$), the model is able to explain the following scattering and thermal emission properties:

1. **Intensity phase functions** (Rosetta/OSIRIS) show U-shaped curves with the minimum around 100 degrees [3]. The model predicts that the location and deepness of the minimum depends on the size of particles.

2. **Superheating factor phase function** (Rosetta/VIRTIS) shows phase dependence indicating temperature gradients inside the particles [4]. The model predict that the particles must

be larger than $10\,\mu m$ to maintain temperature gradients. Temperature gradients also depend on the size, heat conductivity and spinning state of particles.

3. **VIS-NIR spectrum** (Rosetta/VIRTIS) from 0.35 to $3.5\,\mu m$ shows a slightly red spectrum with a small increase in the slope between 0.5-1 μm [5]. The model indicates that color depends on the particle size distribution. Small particles result in a bluer spectrum and large redder.

4. **Silicate feature** (Ground based) is absent at 9-$13\,\mu m$ [6]. Small particles (radius $< 10\,\mu m$) shows a strong $10\,\mu m$-silicate feature but it vanish with increasing particle size.

5. Conclusions

Visible, near and thermal infrared observations of the coma of comet 67P/Churyumov-Gerasimenko indicate that small particles (radius $< 10\,\mu m$) are absent or their number is significantly lower than larger ones in the coma. Hence, the scattering and emission features are dominated by large particles. To obtain better understanding of the internal structure of particles, i.e., grain size and porosity, polarimetric data should be interpreted in combination with the photometric data.

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References

[1] Muinonen, K., Markkanen, J., Väisänen, T., et al.: Multiple scattering of light in discrete random media using incoherent interactions, Optics Letters, Vol. 43, No. 4, pp. 683-686, 2018.

[2] Markkanen, J., Agarwal, J., Väisänen, T., et al.: Interpretation of the Phase Functions Measured by the OSIRIS Instrument for Comet 67P/Churyumov–Gerasimenko, Astrophysical Journal Letters, Vol. 868, No. 1, pp. L16, 2018.

[3] Bertini, I., La Forgia, F., Tubiana, C., et al.: The scattering phase function of comet 67P/Churyumov–Gerasimenko coma as seen from the Rosetta/OSIRIS instrument, Monthly notices, Vol. 469, pp. 404-415, 2017.

[4] Bockelée-Morvan, D., Leyrat, C., Erard, F., et al.: VIRTIS-H observations of comet 67P's dust coma: spectral properties and color temperature variability with phase and elevation, Astronomy&Astrophysics, in press.

[5] Rinaldi, G., Fink, U., Doose, L., et al.: Properties of the dust in the coma of 67P/Churyumov–Gerasimenkoobserved with VIRTIS-M, Monthly Notices, Vol. 462, pp.547-561, 2016.

[6] Hanner, M.S., Tedesco, E., Tokunaga, A.T., et al.: The dust coma of periodic comet Churyumov-Gerasimenko, Icarus, Vol. 64, pp 11-19, 1985.