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Comparison between interplanetary and cometary dust, from polarimetric remote and in situ studies

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Abstract

Properties of dust in the interplanetary dust cloud and in cometary comae are approached through polarimetric observations, including polarimetric imaging and analyses of the phase angle and wavelength dependences. Local changes are clues to changes in the properties of the dust particles. They are likely to correspond to modifications in the size distribution and to evolution processes related to the evaporation (or alteration) of ices and organics partly constituting some dust particles.

1. Intensity and linear polarization observations

Linear polarization of solar light scattered by dust particles forming clouds or regolitic surfaces depends on the phase angle and the wavelength of the observations, as well as on the intrinsic properties of the scattering medium. In the visible domain, phase curves of comets and zodiacal light suggest that the particles are irregular, with sizes mostly above one micron. Intensity and polarization observations provide information on dust properties, such as spatial density, local changes, size distribution, morphology, composition and albedo.
Observations of solar light scattered by interplanetary dust, so-called the zodiacal light, have been used to derive tables and maps in helio-ecliptic coordinates, with a resolution of 5° or larger [1-4]. They are critical for studies of extended faint astronomical sources in the background [3]. Besides, they lead to local information from partial inversion of the line of sight integrated data [2]. The local polarization at 90° phase angle increases with increasing solar distance, at least up to 1.5 au in the ecliptic plane, while the local albedo decreases [2,4].
In cometary comae, evidence for changes in local polarization with the distance from the nucleus and with wavelength (through narrow continuum filters) had been discovered through observations of the OPE instrument on-board the Giotto spacecraft during its flyby of comet 1P/Halley [5]. Since then, numerous remote observations in the visible and near infrared domains have provided clues, through polarimetric imaging techniques, to heterogeneities in the dust properties within cometary comae, with an increase in jet-like polarization signatures (as noticed for 67P/Churyumov-Gerasimenko, the target of Rosetta mission, after its 2009 perihelion passage) and a possible decrease of the polarization in the near-nucleus region [e.g., 6-8]. It was noticed that polarization phase curves provide clues to different type of dust particles in cometary comae, and that the polarization at a given phase angle usually increase with increasing wavelength, at least in the visible domain.

2. Interpretation of observations

Analysis of such studies are revisited, both for interplanetary and cometary dust, with emphasis on the significance of complementary experimental and numerical simulations to provide relevant interpretations. Interplanetary dust and cometary dust particles are noticed to present some significant similarities [9].
Numerical simulations of the polarimetric behaviour of interplanetary dust particles suggest that, in the inner solar system, they consist of absorbing (organic compounds) and less absorbing (silicates) materials, that radial changes originate in a decrease of organics with decreasing solar distance (probably under evaporation processes) and that a significant fraction of the interplanetary dust is of cometary origin [10].
From numerous observations of 1P/Halley and C/1995 O1 Hale-Bopp in various colours, size distributions can be derived, together with the relative bulk contributions of silicate and more absorbing organic material, which remains between 33% and 60% in mass [11]. Changes noticed from innermost comae to outer comae could be attributed

to an evaporation of ices or alteration of organics, after dust is released by a nucleus.

3. Perspectives

Improved links between remote polarimetric observations of cometary dust and in situ data are expected from the ESA Rosetta rendezvous mission to comet 67P/Churyumov-Gerasimenko (mostly from dust instruments, i.e., GIADA, MIDAS, COSIMA) and simultaneous remote polarimetric observations (from HST and other observatories).

An improved resolution in maps of interplanetary dust intensity and polarization is expected from Eye-Sat nanosatellite. This cubesat, mainly developed by students working at CNES, is expected to be launched in piggy-back on a Sun-Synchronous Orbit in 2016.

Such approaches should provide better insights on solar system early evolution, including dust accretion during its formation and delivery of carbonaceous compounds on telluric planets though interplanetary dust particles impacts during its early evolution.

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References

[1] Levasseur-Regourd, A.C. and R. Dumont, Absolute photometry of zodiacal light, Astron. Astrophys, Vol. 84, 277-279, 1980.

[2] Leinert, C., Bowyer, S., Haikala, L.K., et al. The 1997 reference of diffuse night sky brightness, Astron. Astrophys. Supp., Vol. 127, pp. 1-99, 1998.

[3] Levasseur-Regourd, A.C., Mann, I., Dumont, R., et al. Optical and thermal properties of interplanetary dust. Interplanetary dust (Grün et al. Eds), pp. 57-94, Springer-Verlag, 2001.

[4] Lasue, J., Levasseur-Regourd, A.C., Lazarian, A., Interplanetary dust. Polarimetry of stars and planetary systems (Kolokolova et al., Eds), Cambridge University Press, accepted, 2014.

[5] Levasseur-Regourd, A.C., McBride, N., Hadamcik, E. et al., Similarities between in situ measurements of local dust scattering and dust flux impact data within the coma of 1P/Halley, Astron. Astrophys., Vol. 348, 636-641, 1999.

[6] Hadamcik, E. and Levasseur-Regourd, A.C., Light scattering by irregular dust particles in the solar system: observations and interpretation by laboratory measurements, J. Quant. Spectros. Radiat. Transfer, Vol. 79-80, 903-910, 2003.

[7] Kolokolova, L., Hanner, MS., Levasseur-Regourd, AC., et al. Physical properties of cometary dust from light scattering and thermal emission. Comets II (Festou et al., Eds.) pp. 577-604, 2004.

[8] Hadamcik, E., Sen, A.K., Levasseur-Regourd, A.C., et al., Polarimetric observations of comet 67P/Churyumov-Gerasimenko during its 2008-2009 apparition, Astron. Astrophys., Vol. 517, A86, 2010.

[9] Levasseur-Regourd, A.C., Mukai, T., Lasue, J., et al., Physical properties of cometary and interplanetary dust, Planet. Space Sci., Vol. 55, 1010-1020, 2007.

[10] Lasue, J., Levasseur-Regourd, A.C., Fray, N., et al. Inferring the interplanetary dust properties from remote observations and simulations, Astron. Astrophys., Vol. 473, 641-649, 2007.

[11] Lasue, J., Levasseur-Regourd, A.C., Hadamcik, E., et al., Cometary dust properties retrieved from polarization observations, Application to C/1995 O1 Hale-Bopp and 1P/Halley, Icarus, Vol. 199, 129-144, 2009.