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Experimental investigation of agglomeration effects in infrared spectra on micron-sized particles

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Abstract

We demonstrate for the first time experimentally how the agglomerate structure and size affects the extinction spectra of amorphous SiO_2 monosphere particles in the mid-IR region. The experimentally measured extinction spectra of agglomerates with well-defined morphological and structural characteristics are compared with theoretically calculated extinction spectra using different light scattering simulation methods.

1. Introduction

Detailed analysis of observed infrared (IR) dust emission spectra is often performed in order to derive information about mineralogy, particle size, and temperature of the dust. However, the IR bands are also influenced by agglomeration of the dust particles. Light scattering theory simulating agglomeration and growth effects is especially challenged by the consideration of highly absorbing particles.

2. Methods

We construct artificial particle agglomerates by means of the dedicated robotic manipulation (DRM) technique ([2], see Fig. 1). IR microspectroscopic extinction measurements of these arranged particles are performed at the French National Synchrotron Facility, SOLEIL, in the mid-IR region considering polarization effects. The theoretical approaches applied are the discrete dipole approximation (DDA) as well as T-matrix and finite-difference time-domain methods.

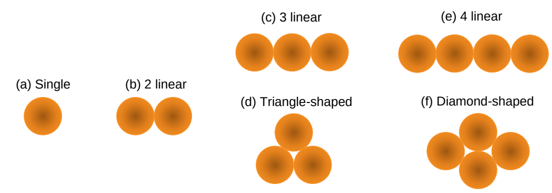

Figure 1: Sketch of the agglomerate structures produced with the DRM technique for microspectrometry and used in the calculations.

3. Results

In both the experimental spectra and the theoretical calculations, we find that the Si-O stretching vibration band at about 9 μm is clearly broadened on the long-wavelength side by the agglomeration of particles (Fig. 2). This is mainly caused by the radiation components, which are polarized in directions in which the agglomerate is extended, while the extinction band profile of the component polarized perpendicular to the long axis of an elongated agglomerate is close to the spectrum of the single sphere. All of the theoretical simulations predict these effects in qualitatively good agreement.

4. Summary and Conclusions

Our comparative study of the experimentally measured and theoretically calculated IR extinction spectra of well-defined agglomerate structures makes obvious how the various particle arrangements in small clusters might contribute to average spectra of dust. Therefore, the study might help to improve the precision of light scattering calculations as well as

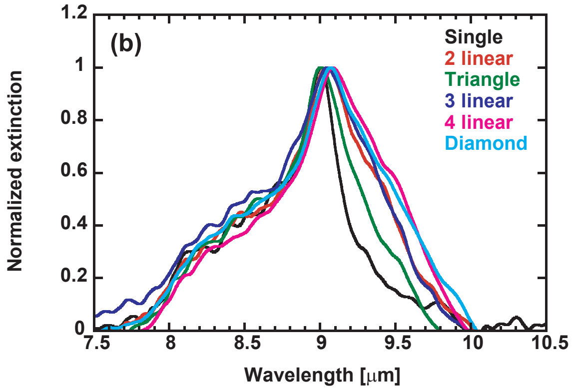

Figure 2: Broadening of the Si-O stretching vibration band by agglomeration of micrometer-sized spherical silica particles as measured in microspectroscopic extinction spectra of linear, triangular and diamond shaped agglomerates. Spectra have been normalized for better comparison.

their specific applicability.

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References

[1] Tamanai, A., Vogt, J., Huck, C., et al.: Experimental verification of agglomeration effects in infrared spectra on micron-sized particles, Astron. Astrophys., Vol. 619, id. A110.

[2] Zimmermann, S., Tiemerding, T., and Fatikov, S.: Automated Robotic Manipulation of Individual Colloidal Particles Using Vision-Based Control, IEEE-ASME T. Mech., Vol. 20, pp. 2031-2038, 2015.