INFRARED EXTINCTION BY AGGREGATES OF SiC PARTICLES

Anja C. Andersen[1], Harald Mutschke[2], Thomas Posch[2,3]

[1]NORDITA, Blegdamsvej 17, DK-2100 Copenhagen, anja@nordita.dk
[2]Astrophysikalisches Institut, Schillergäßchen 2-3, D-07745 Jena, mutschke@astro.uni-jena.de
[3]Institut für Astronomie, Türkenschanzstraße 17, A-1180 Wien, posch@astro.univie.ac.at

Material properties

Silicon Carbide (SiC) is a material with exceptional physical and mechanical properties; low density, high inherent strength, high thermal conductivity, stability at high temperatures and a high resistance to shocks. It is characterized by a *high complex refractive index (|m|>10) and sharp surface resonances between the LO and TO frequencies*. SiC particles are present in carbon star envelopes and as preserved stardust in meteorites.

In this work we use β-SiC data calculated from a Lorentzian oscillator-type dielectric function describing the phonon resonance in the wavelength range 10-13μm (Mutschke et al. 1999). All the clusters consist of homogeneous SiC particles with a diameter of 10 nm embedded in vacuum.

Fig 1: TEM picture of an SiC cluster (Clément et al. 2003).

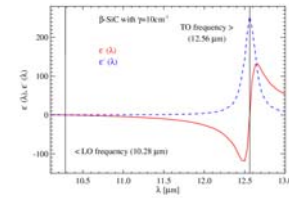


Fig 2: The dielectric functions for β-SiC with damping constant $\gamma = 10\ cm^{-1}$.

DDSCAT vs. SCSMTM

A comparison of calculated extinction cross sections for a chain of 5 particles using the DDSCAT (Draine & Flatau 2004) and the SCSMTM (Mackowski & Mishchenko 1996) codes. The most striking is the *lack of convergence* for both codes despite the relatively high number of dipoles and polar order used.

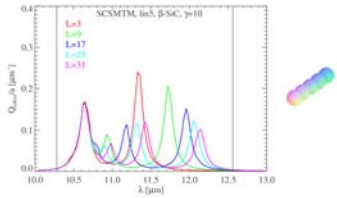


Fig 4: Extinction calculations with SCSMTM

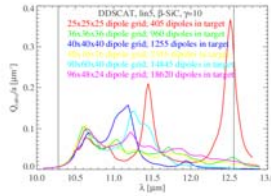


Fig 5: Extinction calculations with DDSCAT.

Trio clusters

Extinction of 3 particle clusters, calculated with the SCSMTM code, illustrates the cluster geometry influence. The interaction between the spheres mainly influences the long-wavelength resonance(s).

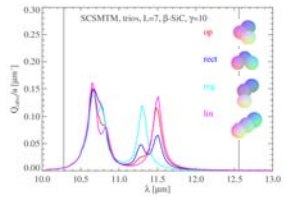


Fig 3: Extinction profiles in the SiC phonon band for four different trios.

Small compact cluster

The calculated extinction of a compact 8 particle cluster using the DDSCAT code. The *choice of dipole grid is significant* for the obtained result; for the cubic 8 cluster a grid which is dividable by 2 is the better choice, while for the semi-fractal 7 particle cluster (Fig. 8) a grid dividable by 3 should be preferred.

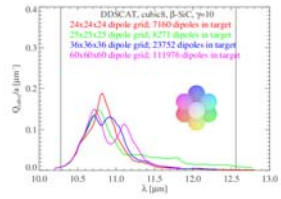


Fig 6: Extinction calculations using DDSCAT. The legend indicates the size of the dipole grid used and the number of dipoles which eventually characterized the cluster.

Linear Clusters

The extinction profile for linear clusters, calculated with the SCSMTM code. Linear clusters of different length give rise to a shift of the long-wavelength peak position. The *shift is dependent on the length of the chain.* An identical result was obtained with the MQAGGR code (Quinten 1993).

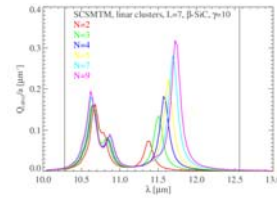
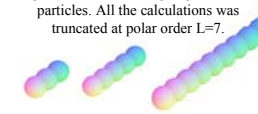


Fig 7: Extinction profile for different length of linear clusters going from 2 to 9 particles. All the calculations was truncated at polar order L=7.



Semi-fractal Cluster

Extinction calculation performed with the SCSMTM code for a 7 particle cluster with fractal dimension of D=1.77. The *long-wavelength peak position correlates with a chain of length 3.* A similar result was obtained using the GA code (Andersen et al. 2003)

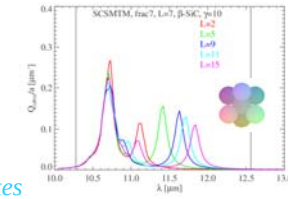


Fig. 8: Extinction profile of a seven particle cluster calculated with SCSMTM. L indicates the polar order for which the calculation was truncated. Note that the result is not yet converged at L=15.

Larger Clusters

The extinction for 16 particle clusters, calculated with SCSMTM, also display a *dependence of the long-wavelength peak which correlates with the length of the longest chain* within the cluster. This is best seen by comparing Fig. 9 with Fig. 7.


Clu16_1


Clu16_2


Clu16_3


Clu16_4

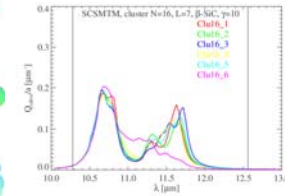


Fig 9: Extinction of SiC clusters consisting of 16 particles. Calculated using SCSMTM to polar order L=7.


Clu16_5


Clu16_6

Acknowledgements

We thank B.T. Draine & P.J. Flatau for making their DDA code (DDSCAT) and D.W. Macowski and M.I. Mishchenko for making their T-matix (SCSMTM) code available as shareware. We are grateful to Akemi Tamanai for producing coordinates of the 16 particle clusters. HM acknowledges support by DFG grant Mu1164/5 and TP acknowledges hospitality by the Austrian Army.

References

Andersen A.C., Sotelo J., Pustovit V., Niklasson G., 2002, A&A 386, 296 (GA)
Clèment D., Mutschke H., Henning Th., 2003, ApJ 594, 642
Draine B.T., Flatau P.J., 2004, http://arxiv.org/abs/astro-ph/030969 (DDSCAT)
Mackowski D.W., Mishchenko M.I., 1996, J. Opt. Soc. Amer. A 13, 266 (SCSMTM)
Mutschke H., Andersen A.C., Clèment D., Henning Th., Peiter G., 1999, A&A 345, 187
Quinten M., Kreibig U., 1993, Appl. Opt. 32, 6173 (MQAGGR)

NORDITA Nordic Institute for Theoretical Physics