American Association for Aerosol Research

Included in Issue: Spring 2023

Aerosol Science & Technology Journal Highlight

By Sarah Petters, Aarhus University

Finding the color of sand: Thermal infrared, shape factor, and extraordinary rays

"Complex refractive index of crystalline quartz particles from UV to thermal infrared"
Hervé Herbin, Lise Deschutter, Alexandre Deguine, and Denis Petitprez, Univ. Lille, CNRS, Lille, France

Read the full article:
Herbin, H., Deschutter, L., Deguine, A., and Petitprez, D. (2023). Complex refractive index of crystalline quartz particles from UV to thermal infrared. Aerosol Science and Technology 57 (3):255–265. https://doi.org/10.1080/02786826.2023.2165899.

You've seen it in museum shops and in sand boxes. It keeps the time in your watch. Silicon dioxide (quartz) is ubiquitous on Earth and forms a dominant part of other rocky planets in the solar system. As mineral dust, SiO_2 plays an important role in the redistribution of radiation in the atmosphere.

But what color is it, really? The optical properties of the bulk material are different from those of the aerosolized powder. Radiative transfer depends on the size distribution, refractive index of the material (real and imaginary parts), and radiation wavelength. This calculation is especially hard for crystalline SiO_2.

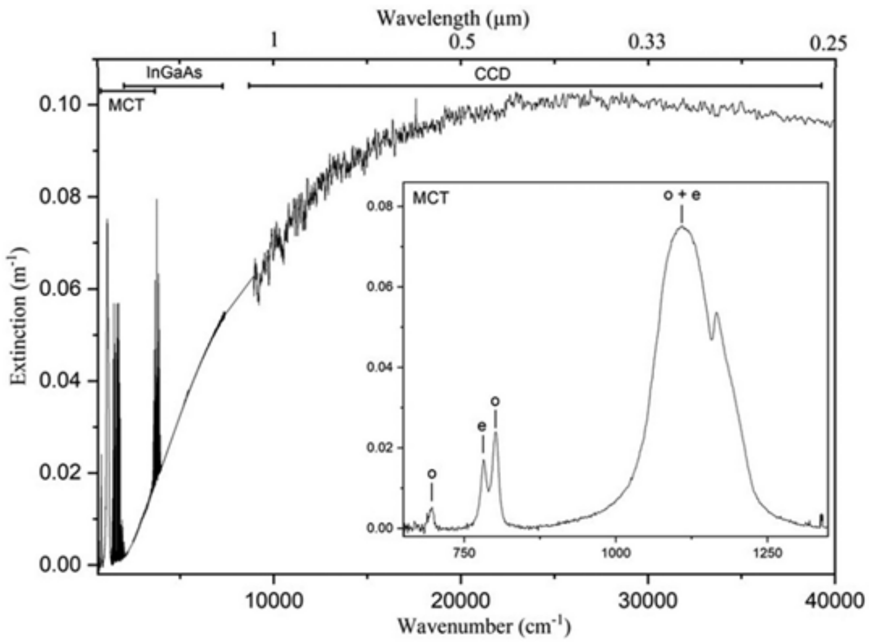
Recently, Herbin and co-authors at the University of Lille (France) measured the extinction and size spectra of aerosol quartz in a closure study aimed at correcting the refractive index for quartz aerosols in a spectral range useful for remote sensing (Herbin et al., 2023). They started their extinction measurement in the thermal infrared (TIR, 650–1350 cm^{-1}, 7–15 µm wavelength) and scanned all the way to short-wave UV (40,000 cm^{-1}, 250 nm). In the TIR region (inset of Figure 2) you can see with clarity the separation of rays in the birefringent material (o-, e-, and o+e absorption peaks, particularly near 800 cm-1). You will have to read the article to see what is extraordinary about the 'e' peak.

Particle number-size distributions were measured with a scanning mobility particle sizer and an aerodynamic particle sizer, revealing a significant but expected non-spherical shape (a χ value of about 1.33) – the mode diameter was about 200 nm. The irregular particle shape is revealed as an important factor in infrared remote sensing of dust.

The authors close the gap between the model of the extinction spectrum – formulated using Mie theory – and the measured extinction spectrum. Mie theory has generally performed well for non-spherical particles, except in the TIR region of the spectrum. The non-spherical and birefringent properties of quartz introduce spectral features here that were not well captured by prior models. A non-spherical adjustment (namely, the continuous distribution of ellipsoids (CDE) model) performed very well for the spectral features observed in the TIR – and also performed well to reproduce an extinction spectrum measured using the same setup for a distinct SiO2 sample.

Figure 2 of 6

Figure 2. Extinction spectrum of quartz between 650 and 40,000 cm^{-1}. The spectral range 8500–9500 cm^{-1} is very noisy, the plot in this gap corresponds then to linear interpolated data. The two strong rovibrational absorption bands around 1600 and 3600 cm^{-1} are due to residual water vapor and they are therefore removed in the CRI calculation. The inset shows a zoomed portion of the extinction spectrum in the TIR (between 650 and 1350 cm^{-1}) where the o- and e-rays are pointed out by vertical lines.



This Issue's Newsletter Committee:

Editor | **Krystal Pollitt,** Yale University

Senior Assistant Editor | **Justice Archer,** University of Bristol

Junior Assistant Editor | **Dong Gao,** Yale University

Guest Contributor | **Sarah Petters**, Aarhus University