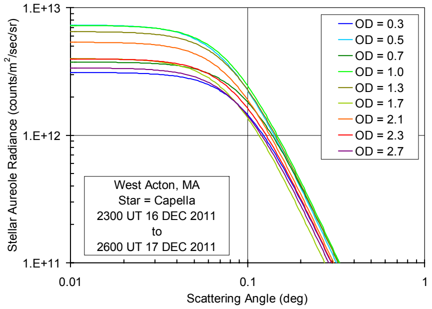
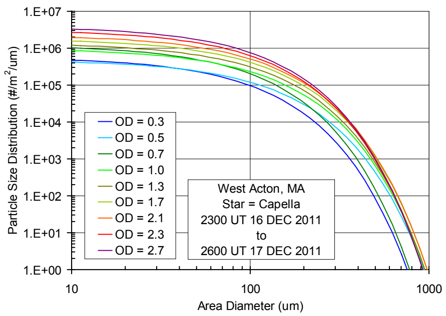
Example retrieved aureole profiles.



6. PSD Retrieval

An approximation to the aureole radiance using an exponential particle size distribution is one way to retrieve the PSD parameters (see panel 5).

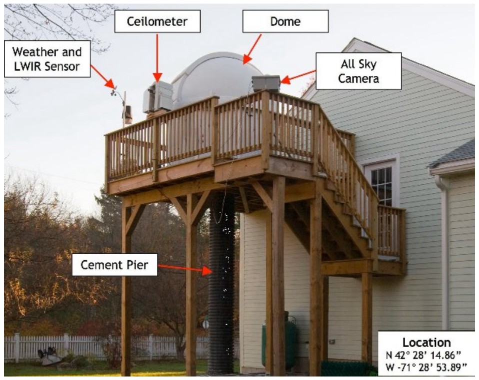


7. SBIR Phase I Datasets

40 hours of stellar aureole data from 16 nights (between 19 JUN 2011 and 26 FEB 2012) were collected in the 672 nm band using multiple exposures to extend the dynamic range. Sky conditions ranged from clear to COT ~5 with primarily cirrus and some water clouds. Supporting data include simultaneous COT from a second camera, all-sky imagery, a laser ceilometer, and both local and synoptic weather data.

8. Conclusions

This work demonstrates that (1) we have clearly measured stellar aureole profiles; (2) we can follow the aureole profiles out to ~1/4 degree from stars (~1/2 degree from Jupiter); (3) the stellar aureoles from cirrus have very distinctive profiles, being flat out to a critical angle, followed by a steep power-law decline with a slope of ~-3; (4) the profiles are well modeled using exponential size distributions; and (5) the critical angle in the profiles is ~0.12 degrees, (6) indicating that D_0 ranges from ~150 to ~200 μm.



9. Acknowledgements

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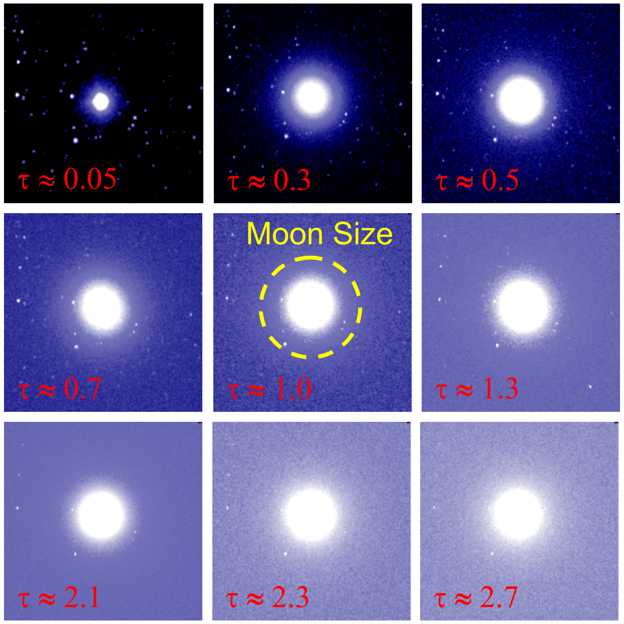
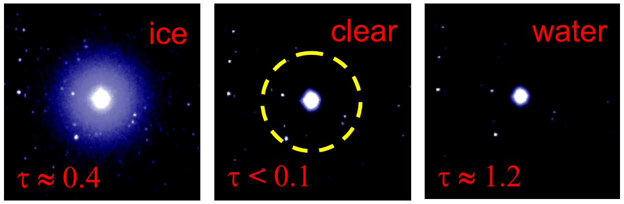


Retrieving Cirrus Microphysical Properties from Stellar Aureole Images



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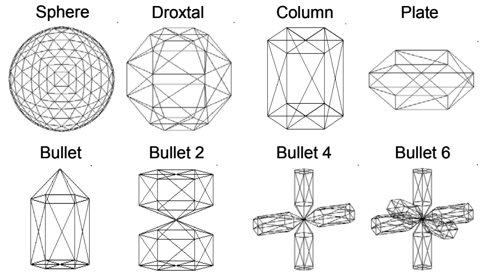
1. Background / Introduction

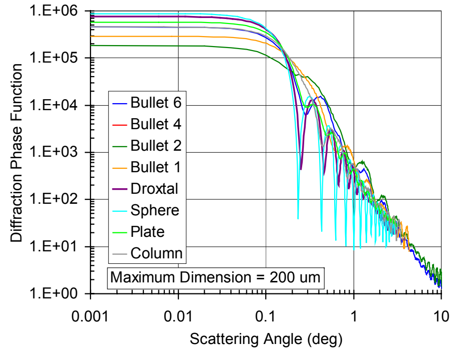
While knowledge of the impact of aerosols on climate change has improved significantly due to the routine, ground-based, sun photometer measurements of aerosols made at AERONET sites world-wide, the impact of cirrus clouds remains much less certain because they occur high in the atmosphere and are more difficult to measure. We report on a Phase I SBIR project to retrieve microphysical properties of cirrus ice crystals from stellar aureole imagery.

2. Cirrus Crystal Diffraction

Consider diffraction from a variety of crystal habits.

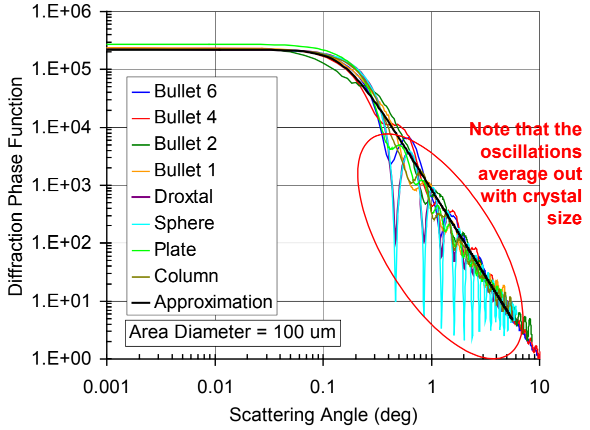


Diffraction phase functions vary greatly for crystals with the same maximum size.



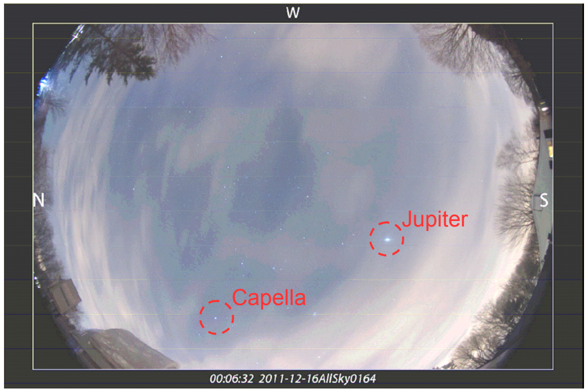
3. Area Diameter

Diffraction phase functions are similar for crystals with the same average projected area. Define the area diameter in terms of a circle with the average projected area. A simple analytic approximation works well to model diffraction for crystals characterized by their average projected area.



4. Examples

This all-sky image shows urban-illuminated cirrus in front of the star Capella.



http://www.westactonastro.com

5. Aureole Interpretation

Aureole profiles are fit simultaneously with models of the point spread function, diffraction aureole, and background.

$$\text{Dif Phase Fun}: \quad P(\theta, D) \simeq \frac{1}{2}\frac{(\pi D/\lambda)^2}{[1+(\pi D\xi/\lambda)^3\theta^3]} \quad (\xi \approx 0.78)$$

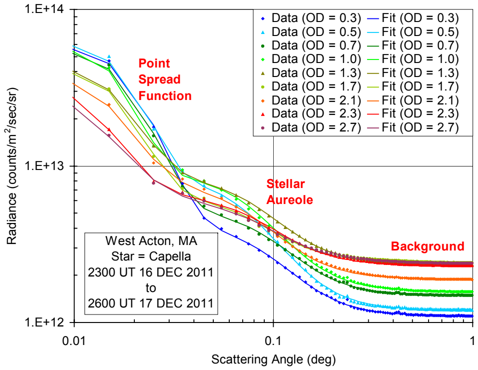
$$\text{Ext Cross Section}: \quad \sigma(D) \simeq 2\,\frac{\pi D^2}{4}$$

$$\text{Part Size Dist}: \quad n(D) \propto e^{-D/D_0} D^{\mu} \quad (\text{with } \mu \text{ set to } 0)$$

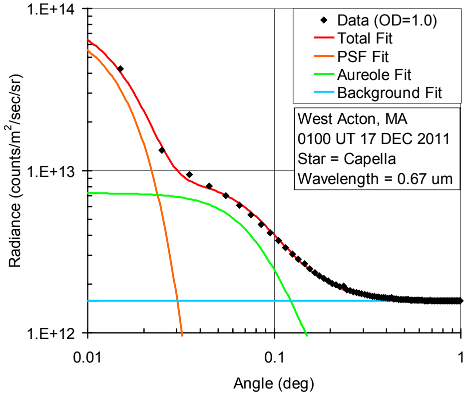
$$\text{Aur Rad}: \quad I(\theta) \propto \int_0^{\infty} \sigma(D) \times P(\theta, D) \times n(D)\, dD$$

$$\propto \left(\frac{D_0}{\lambda}\right)^2 \frac{F_{\rm star}\,\tau\, e^{-\tau}}{[1+(\pi D_0\chi/\lambda)^3\theta^3]} \quad (\chi \approx 2.24)$$

$$\text{Point Spread Fun}: \quad PSF(\theta) \simeq \frac{I_0}{[1+(\theta/\theta_0)^2]^{\beta}}$$



The least-squares fit separates the three components.



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