Contribution of weak localization to lidar returns from atmospheric particles

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Lidars have been widely used to detect clouds and aerosols in the atmosphere, and the particle properties can be retrieved from their lidar backscattering signals upon a series of assumptions and approximations. The lidar returns from atmospheric particles might be enhanced by weak localization in both single scattering and multiple scattering processes, depending on particle properties and the off-backscatter observation angle of lidar.

The lidar returns from large aerosol particles and cloud particles may be enhanced by weak localization in single scattering. Solution of Maxwell's equations to the problem of single scattering can be expanded into iterative series in an order-of-scattering form, where the interference between conjugate terms representing reversible sequences of elementary scatterers is constructive at the backscattering direction, resulting in a coherent backscatter enhancement (CBE) [1]. The backscattering phase function of randomly oriented particles is amplified by CBE with an amplification factor between 1 and 2 depending on particle habit and refractive index. The angular width of the CBE-induced backscattering peak line for a specific particle habit is inversely proportional to the particle size parameter, and CBE peak of cloud and weakly absorbing aerosol particles is wide enough to enhance the returns of most actual lidars.

Lidar backscatter might also be enhanced by interference between conjugate reversible wave paths in multiple scattering (coherent backscattering [2]). However, the angular width of the coherent backscattering peak line in multiple scattering is narrow due to the relatively large distances between neighboring cloud and aerosol particles, so the spaceborne lidar returns would not be enhanced by coherent backscattering due to relatively large off-backscattering observation angle.

References

[1] Zhou, C., 2018: Coherent backscatter enhancement in single scattering. *Opt. Express,* **26**, A508–A519.

[2] Mishchenko, M. I., L. D. Travis, and A. A. Lacis, 2006: *Multiple Scattering of Light by Particles: Radiative Transfer and Coherent Backscattering*. Cambridge University Press, Cambridge, UK.

Preferred mode of presentation: Oral