Backward Glory Scattering In Meteorology, Nuclear Physics and Astrophysics.

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Abstract.

The structure of an out-of-reach object can be studied by sending waves of radiation and observing their refraction, reflection or diffraction, as these waves return to the investigator at angles around 180^0. Knowing how this radiation interacts with the object and how it propagates through the medium, we are able to gather considerable information about the object itself.

Backward glory was first observed and studied in meteorology, the sun being the strong and parallel light source, fog water droplets being the object and electromagnetic waves being the radiation field. The shadow of an observer on a layer of fog, which serves as a screen, was used to determine the 180^0 angle. Maxwell equations, solved by Mie and Van Hulst, were then used to calculate the proper diffraction colored rings. The measured quantity was the radius of the water droplets. The white background of fog is due to incoherent scattering of light on many droplets. The diffraction picture of glory backward scattering is called the Brocken effect and was observed in the 19^{th} century or even earlier. Brocken is a peak in the Harz mountains (Germany) where this effect was seen frequently.

Glory backscattering in nuclear physics was first observed by the Cracow group in the process of elastic scattering of 25 MeV alpha particles on ^{40}Ca nuclei. The angular distribution around 180^0 could be described by a zero-order Bessel function, as predicted by the Mie theory for light scattering from water droplets. In general, proper description of the backward glory scattering requires an optical model of the interaction between the particles and the nucleus. The wave properties of the particles are responsible for the diffraction shape of the angular distribution. The presence and the radius of the atomic nucleus or its matter density distributions can then be deduced from glory backscattering. As pointed out by Bryant and Jarmie, glory backscattering can also be observed in elastic scattering of pions on nuclei.

A theoretical attempt has also been made to study glory scattering of scalar waves or gravitational waves with spin 2 from black holes, which could lead to the determination of the Schwarzschild radius. While present attempts to verify such studies experimentally seem to be out of bounds, who knows what is their future?