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Fast Models of Multiple Lyman-Alpha Scattering in Planetary Exospheres

Lyman-alpha emission is an important tool for observing atomic hydrogen in planetary exospheres. When the medium is optically thin, the measured brightness is approximately proportional to the hydrogen density integrated along the line of sight. At lower altitudes, however, photons can be absorbed and scattered several times before reaching the observer. The measured brightness then depends on hydrogen outside the direct line of sight, making the interpretation of Lyman-alpha images more difficult.

We are exploring ways to make these radiative-transfer calculations fast enough to use inside an inverse problem, where the forward model must be evaluated many times. We are studying two approaches. The first reduces the multiple-scattering operator so that the main nonlocal interactions can be calculated with fewer operations. The second uses a surrogate trained on more complete radiative-transfer calculations to estimate corrections to simpler optically thin or single-scattering models. We will compare their accuracy and computational cost over different hydrogen distributions and optical depths. We will present the physical formulation and preliminary tests toward a fast model that could eventually be used to infer exospheric hydrogen density and temperature from Lyman-alpha observations.

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