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FOUR-TERM SPHERICAL HARMONICS APPROXIMATION FOR RAPID RADIATIVE TRANSFER CALCULATIONS IN EXOPLANET ATMOSPHERES

Abstract

The James Webb Space Telescope will unlock a plethora of high-resolution spectra of some of our universe's most distant objects. Analysis of such spectra requires frequent solutions to the integro-differential radiative transfer equation. Exact solutions for the radiative transfer equation in a scattering and absorbing atmosphere typically do not exist; thus, we rely on approximate methods to estimate solutions. However, a serious challenge in radiative transfer theory is the derivation of computationally efficient methods that have sufficient fidelity to the more exact, numerically intricate solutions. The most simple and widely-used approximations to the radiative transfer equation are known as "two-stream" methods, however, such methods have severe limitations to approximate highly asymmetric phase functions typical of the particulate scattering in cloudy atmospheres. Here we present a novel approach using higher-order spherical harmonics to improve approximation accuracy whilst retaining the necessary computational efficiency needed for use in retrieval studies on JWST data.