Title:	Mahakal : a Python-based Modular Ray-tracing and Radiative Transfer Algorithm for Curved Space-times
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Abstract:	We introduce Mahakala, a Python-based, modular ray-tracing code for geodesic inte- gration in curved space-times. We employ Google's JAX framework for accelerated auto- matic differentiation, which can efficiently compute Christoffel Symbols directly from the metric. This allows the user to easily and efficiently simulate photon trajectories through non-Kerr metrics. JAX also enables Mahakala to run in parallel on both CPUs and GPUs and achieve speeds comparable to C-based codes. Mahakala natively uses the Cartesian Kerr-Schild coordinate system, which avoids numerical issues caused by the "pole" of spherical coordinates. We demonstrate Mahakala's capabilities by simulating the 1.3 mm wavelength images of general relativistic magnetohydrodynamic (GRMHD) simulations of low-accretion rate supermassive black holes. The modular nature of Mahakala allows us to quantify the relative contribution of different regions of the flow to image features. We show that most of the emission seen in 1.3 mm images originates close to the black hole. We also quantify the relative contribution of the disk, forward jet, and counter jet to 1.3 mm images. This thesis is based on our original work [Sharma 23].
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