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Strong Lensing Cross Section for the Singular Isothermal Sphere with Elliptical Sources

Since the late 1980s, when the first gravitational arcs were observed, the strong effect of gravitational lensing has been a key observable in both Cosmology and Extragalactic Astrophysics. This phenomenon predicted by General Relativity, whose effect is the distortion and magnification of the image of a distant cosmic object (source) due to the deflection of the light's trajectory caused by the local space-time curvature created by another object (lens), has many applications, from obtaining the matter distribution of galaxies and galaxy clusters, to testing modified gravity models and measuring cosmological parameters. In view of this importance, we sought in this work analytical and approximate expressions of certain important quantities in the modeling and observation of gravitational arcs. In our research, we make use of the Singular Isothermal Sphere (SIS) model to describe the lens and consider an uniform elliptical source. This model, although simple, describes the phenomenon of gravitational lensing by galaxies with good accuracy, as the total distribution of matter (baryonic + dark matter) in massive elliptical and lenticular galaxies is very close to the one in the SIS model. In fact, the simplicity of this model is a good feature, as we were able to find analytical approximations in the low ellipticity regime, for the length and width of the arcs and, in particular, in addition of small font sizes, of the so-called cross section for arc formation. These solutions not only help us in the physical interpretation of observational results, but also in numerical methods for fitting models to observations. This will be particularly useful considering the substantial increase in galaxy-galaxy strong lensing systems predicted to be discovered by the LSST, Nancy Grace Roman Space Telescope and Euclid spacecraft expected in the upcoming years.

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