Simulating Gravitational Lensing Effect using Python

Abstract

Since Albert Einstein published the famous general theory of relativity in 1915, gravitational lensing has been one of the most powerful tools to observe the universe. Gravitational lensing has an analogy to the optics of convex lens, so it could be understood geometrically. In optics light beams bend traveling through transparent materials that have different indices of refraction, whereas in general relativity the light beams simply follow the curvature of the spacetime that is distorted due to massive astronomical objects. For instance, a beam of light departs from background sources and passes by a lensing object that is in the line of sight, the light looks bent as if it went through a convex lens. The deflection angle due to gravitational lens is explicitly expressed in a single line of equation from general theory of relativity. The angle depends on mass of the lensing object and angular distance from the lensing object. In the same context of convex lens, we can observe the bent light beam as a single image or multiple images magnified and distorted. In a great favor of Einstein's theory, we can simulate simple cases of gravitational lensing effect - microlensing effect. This method is also has been well used to look for extraterrestrial planets. The purpose of this project is to build up a simulation for the micro gravitational lensing effect and to understand how the results provide physical sense of the effect.