arXiv:astro-ph/9508109 24 Aug 95

SIMULATION OF MICROLENSING LIGHTCURVES BY COMBINING CONTOURING AND RAYSHOOTING

STEIN VIDAR HAGFORS HAUGAN
Institute of Theoretical Astrophysics, University of Oslo
Pb. 1029, Blindern
N-0315 OSLO
http://www.uio.no/~steinhh/index.html

1. Introduction

The contouring methods described by Lewis et al. (1993) and Witt (1993) are very efficient for obtaining the magnification of a point source moving along a straight track in the source plane. For finite sources, however, the amplification *must* be computed for numerous parallel tracks and then convolved with the source profile. Rayshooting, on the other hand, is an efficient algorithm for relatively large sources, but the computing time increases with the inverse of the source area for a given noise level.

2. The hybrid method

By using the method described in Lewis et al. (1993), all the images of a straight, infinite line in the source plane can be found. The images are the borders between those parts of the lens plane projected above the straight line, and those parts projected below the straight line. After finding the images of one line below the source and one line above the source, it is clear that those parts of the lens plane that are projected between the two infinite lines in the source plane are the areas between the images of the infinite lines.

Furthermore, those segments corresponding to the upper and lower edges of a box surrounding the source may be identified. The end points of these segments are projected onto the corners of the "source box". Starting from the corner points, the contouring method can be "turned around" 90 degrees, and all the lines joining all the corner points of the "source box" are found. After this step, all the images of the source box are placed within known, closed polygons. Rayshooting is then performed within all the closed polygons, and the lightcurve is produced in the usual way.

3. Efficiency

The efficiency of the rayshooting part of the method compared to crude, non-optimized rayshooting can be found by comparing the size of the areas where rayshooting has to be performed. A target area in the source plane with length $2l$, and height $2r_\mathrm{s}$ gives an effective lightcurve length $L_\mathrm{c} = 2l - 2r_\mathrm{s}$, where r_s is the source radius. The theoretical efficiency f can be shown to be given by

$$f \approx \begin{cases} (1 + \frac{10\sqrt{\kappa_*}}{r_\mathrm{s}} + \frac{100\kappa_*}{l r_\mathrm{s}}) & \text{For } l \gg r_\mathrm{s} \\ (1 + \frac{20\sqrt{\kappa_*}}{r_\mathrm{s}} + \frac{100\kappa_*}{r_\mathrm{s}^2}) & \text{For } l = r_\mathrm{s},\ L_\mathrm{c} = 0. \end{cases} \quad (1)$$

4. Discussion

The above arguments give a theoretical efficiency factor on the order of 10^5 for e.g. a snapshot of the source with $r_\mathrm{s} = 0.01$, $l = r_\mathrm{s}$ and $\kappa_* = 0.4$. However, the most time-consuming task for the hybrid method is going to be the contouring itself. For a snapshot like the example above, the contouring amounts to about 10^5 shots (Lewis et al., 1993). This must be compared with the total number of shots necessary to get a specific signal to noise ratio, generally about 10^3 shots. The highest estimates of f thus have to be lowered by roughly a factor of 100, depending on the specific parameters r_s, κ_*, γ, and l.

Even so, the proposed hybrid method has the potential to be a very efficient workhorse for producing accurate model lightcurves for small but extended sources.

Acknowledgments

The author would like to thank Rolf Stabell and Sjur Refsdal for comments during the preparation of this poster.

References

Lewis, G. F., Miralda-Escude, J., Richardson, D. C., Wambsganss, J. 1993, MNRAS, 261, 647

Witt, H. J. 1993, ApJ, 403, 530