GRAVITATIONAL MICROLENSING BY RANDOM MOTION OF STARS: MOVIE AND ANALYSIS OF LIGHT CURVES

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Abstract. We present a quantitative analysis of the effect of microlensing caused by random motion of individual stars in a galaxy lensing a background quasar. We calculate a large number of magnification patterns for positions of the stars slightly offset from one frame to the next, and thus obtain light curves for fixed quasar and galaxy positions, only due to the change in the relative star positions. These light curves are analyzed to identify microlensing events, which are then classified with respect to height, duration, and slope. These random motion microlensing events are compared with the corresponding ones caused by the bulk motion of the galaxy.

We find that microlensing events produced by random motion of stars are shorter, steeper, and more frequent than bulk motion events, assuming the velocity dispersion of the stars equals the bulk velocity of the galaxy. The reason for this difference is that in the case of random motion, caustics can move with an arbitrarily high velocity, producing very short events, whereas in the comparison case for bulk motion a microlensing event can never be shorter than it takes a fold caustic, which moves with the velocity of the lensing galaxy projected onto the quasar plane, to cross the quasar. An accompanying video illustrates these results. For three different values of the surface mass density κ, it shows time sequences of 1000 magnification patterns for slowly changing lens positions, together with the positions and velocity vectors of the microlensing stars. The full paper including the video can be found in Wambsganss & Kundić (1995). A short version of the video is available as an MPEG movie under anonymous ftp at astro.princeton.edu, in the directory `jkw/microlensing/moving_stars`.

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1. Description of accompanying video

The accompanying video (Wambsganss & Kundić 1995) consists of four sequences: one header sequence, in which the film is described, and three sequences of 1000 magnification patterns calculated for random motion of stars, one sequence each for surface mass densities of $\kappa = 0.2, 0.5, 0.8$. The film shows the changing caustic network for stars moving with velocities drawn from a Maxwellian distribution.

The video screen consists of four panels: the lower left shows the magnification pattern at any given time. The lower right displays positions of stars at that time, so that one can correlate single, double, and multiple lens caustics with the corresponding lenses. Velocity vectors at the lenses – small lines of different length and direction – indicate where the stars are heading. Both of these panels change with time. In addition, there are two panels at the top, indicating microlensing light curves. At the top left we show one light curve for bulk motion: it is just a horizontal cut through the magnification pattern, i.e. so far the "standard" microlensing light curve for fixed positions of the stars and only bulk motion of the lensing galaxy. Because the magnification pattern changes as time goes on, so does this light curve. An example for the new light curves determined for random motion of lenses is shown at the top right panel of the video screen. It is obtained at the central point of the magnification pattern. This light curve is fixed for the whole sequence; it is pre–calculated. All that changes is a black vertical line inside the light curve, indicating "time" or "frame number". In other words: for fixed positions of observer, lensing galaxy and quasar, the observer would see such a light curve with time due to the stars moving inside the galaxy.

After each such sequence for the three values of the surface mass density κ, the changing magnification pattern alone is shown in higher resolution, filling the whole screen (i.e., without the panels with the positions of lensing stars and light curves). This is done in order to allow a more detailed look at the way the caustics move and merge with each other. Finally, the three sequences are shown again, slowed down by a factor of five, so that one can follow the evolution of individual caustics and the motion of the stars producing them. The total duration of the video is about 18 minutes.

References

Wambsganss, J. & Kundić, T., 1995, ApJ, in press

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