PROSPECTS FOR THE DETECTION OF MICROLENSING TIME DELAYS

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Abstract. Since the image separations produced by microlensing are inaccessible to observation, we are left to observe either a change in total amplitude or the time delay between the images. Spillar (1993) has suggested that a time delay might be observed in the autocorrelation of a microlensed signal. The time delays are of order a few microseconds and are easily accessible to a sufficiently wide bandwidth system. We calculate expected observational results using the Green Bank Telescope with a VLBA recording system, and find that brightness temperatures exceeding the Compton limit are required for detection.

1. Discussion

We consider microlensing of a background source (e.g. an AGN) by a single Schwarzschild potential in some intervening galaxy (or galaxy halo). In what follows, we take $q_0 = 0.5$, $H_0 = 80\,\mathrm{kms^{-1}Mpc^{-1}}$, $z_s = 1.0$, $z_l = 0.05$, lens mass = $M_\odot$, and a uniform disc source of flux density 100 mJy. For a point source lensed by a single Schwarzschild potential the observed electric field is given in terms of the field that would be observed if there were no lens, $E(t)$. The observed field consists of two parts, one for each image: $\sqrt{\mu_1}E(t) + \sqrt{\mu_2}E(t+\Delta)$ where Δ is the gravitational lens time delay and $\mu_{1,2}$ are the magnification factors for the two images. The autocorrelation of this signal has three terms, the first of which appears at $\rho = 0$ and corresponds to the total power of the two images added together. The second two terms appear at $\rho = \pm\Delta$ and allow us to measure the gravitational time delay and $\sqrt{\mu_1\mu_2}$. When observing with limited bandwidth, the observed autocorrelation is convolved with the autocorrelation of the impulse

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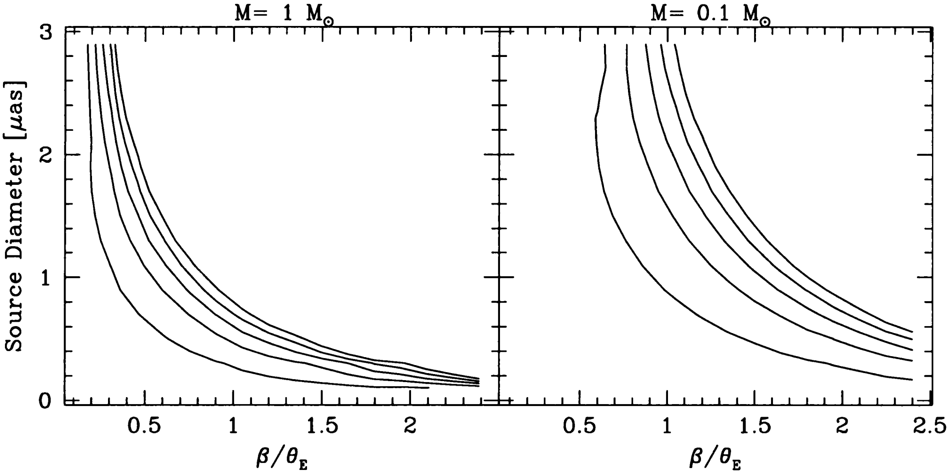
response function of the bandpass filter. For the VLBA 16 MHz bandpass, the first zero occurs at a lag of 3.5×10^{-8} sec.

If the source is not point-like and different regions radiate incoherently, then one can divide the source into a large number of point sources and sum their contributions to the autocorrelation signal. We have written software which generates a predicted autocorrelation function from a distribution of flux density on the sky, a bandpass, and the relevant lens parameters.



Figures 1 and 2 (above) show the observation time necessary to obtain a 3σ single channel detection for various combinations of source size, lens to source distance, and lens mass. The contours are at intervals of two hours starting at 1 hour. Detection in less than 10 hours observation time requires sources with apparent $T_B \sim 10^{15}$ K which exceeds the Compton limit. Such high brightness temperatures are suggested by studies of intra-day variability in AGN which report T_B as high as 10^{19} K inferred from variability (Quirrenbach et al. 1992).

2. Conclusions

We have shown that microlensing time delays should be visible with large telescopes if there are high apparent T_B sources and a sufficient mass density of lensing objects. Remaining to be considered explicitly are the effects of scintillation, the effect of multiple lensing events on detectability, and the special case of a lens with a diffuse object directly behind it.

References

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