SOME REMARKS ON GRAVITATIONAL MICRO-LENSING

Sjur Refsdal and Rainer Kayser
Hamburger Sternwarte
Gojenbergsweg 112
D-2050 Hamburg 80
F.R. Germany

ABSTRACT. Gravitational micro-lensing can be used to obtain information 1) on the inner structure of active galactic nuclei and 2) on the distribution of compact masses in the range 10^{-4} ... 10^{2} solar masses. A regular monitoring of the most promising candidates for micro-lensing should be carried out. The strongest candidate is the macro-lensed quasar 2237+030, for which we expect a change in the luminosity ratio between the images of about 5 per cent per year.

Stars or other compact objects close to the light path in an intervening galaxy ("macro-lens") can act as gravitational "micro-lenses". This can lead to a splitting-up of a "macro-image" (produced by the galaxy) into several "micro-images" [1] and to large variations in brightness due to transverse motions [2]. The separations between the micro-images are of the order micro-arcseconds for solar mass stars and cosmological distances, i.e. not resolvable, however, the brightness variations in the (unresolved) macro-images can be several magnitudes.

Of special interest are the so-called high amplification events (HAE) which occur when the observer crosses a caustic of the micro-lenses [1,2,3]. It is well known that the number of (micro-) images changes by two if the observer crosses a caustic, i.e. a HAE is similar to an eclipse: the source appears (or disappears) in two (micro-) images. Thus, one can retrieve the one-dimensional intrinsic source profile from an observed HAE light curve [4]. This offers the possibility to obtain information on the inner structure of compact AGN. The true size of the source can be determined if the transverse velocity between observer and caustic is known. This velocity can be determined from the "parallax-effect" [4,5], using a space-borne telescope $\gtrsim 1$ A.U. away from the earth. Micro-lensing leads to a brightness gradient in the observer plane, which can reach values of up to 0.1^{m}/A.U. during a HAE.

Note that the measurement of such a brightness gradient is the only way (with the exception of multiple quasars with known time delays) to distinguish gravitational micro-lensing definitely from intrinsic variability [6].

For larger baselines ($\gtrsim 100$ A.U. for solar mass stars) a significant fraction of distant quasars should show measurable brightness

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gradients even without HAE. Such measurements could give important information on the distribution of masses in the range of 10^{-4} ... 10^{2} solar masses and on the size of quasars. It should be checked whether planned spacecrafts can be used for such a program. Spectacular large baselines would be offered by a project like the astrometry probe TAU ("Thousand Astronomical Units") recently proposed by the JPL [7]. The effect discussed here gives strong additional arguments for such a mission.

The most promising candidates for gravitational micro-lensing are 1) quasars with two or more macro-images, 2) quasars with foreground galaxies close to the line of sight, 3) quasars showing absorption line systems with a redshift much less than the emission redshift and 4) quasars with an exceptional high absolute luminosity. A regular monitoring of the best candidates should be done in order 1) to prove the existence of the effect and 2) to measure HAE lightcurves with high accuracy. Such a program is now being planned [8].

Up to now the observational indications for gravitational micro-lensing are not convincing. The observed variability of the macro-lensed quasars 0957+561 A,B and 1115+080 are difficult to understand without micro-lensing [4], however more and better data are here badly needed.

A very strong candidate for micro-lensing is 2237+030 [9], showing four components distributed nearly symmetric around the centre of a barred spiral galaxy [10,11] . For all four (macro-)images the local shear term [1,2] must be near $|\gamma| = 1$, leading to an enhanced variability due to micro-lensing and larger probability for the occurrence of HAE. Since the time delay between the images for this system is of the order of one day intrinsic changes should show up "simultaneously" in the four images. A variation of the luminosity ratio between the images would therefore be a proof of micro-lensing. From numerical simulations [2] we expect changes in the luminosity ratios of about 5 per cent per year, even if the quasar radius is as large as ≈ 0.03 pc and if only 10 per cent of the galaxy mass is in stars. For a quasar radius smaller than 0.003 pc we usually get HAE ($\Delta m \gtrsim 1^{m}$) with a frequency (for all images) roughly estimated to be 0.5 per year.

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