WeCAPP – Searching for Dark Matter in M31

WeCAPP is a long term monitoring project searching for microlensing events towards M31. A search for very high (S/N), short time scale events in a fraction of the data has resulted in two events WeCAPP-GL1 and GL2. Modelling the stellar content of bulge and disc and assuming a 100% MACHO halo fraction yields that halo lensing is more likely than self lensing, and that the most probable masses are in the range of the brown dwarf limit of hydrogen burning.

Motivation

Studying the lensing effect of foreground objects to background stars towards M31 allows to statistically separate between self-lensing and true MACHO events: the high inclination of M31 (77°) produces a near-far asymmetry of the hale event rate. The near side of the disk will show less halo events than the more distant one. In contrast Galactic halo-lensing as well as self-lensing events should not show this asymmetry after the effect of dust has been taken into account. As most of the sources for possible lensing events are not resolved at M31's distance of 770 kpc the difference imaging technique (Alard & Lupton 1998) has to be applied to identify these so called 'pixellensing' events (Gould 1996).

Fig. 1 V-,R-, and I-band composite image of the observed field of the M31 bulge taken at Calar Alto Observatory with a field of view of 17.2 arcmin (3.75 kpc).

WeCAPP-GL1 and GL2

In the data covering the years 2000/2001 we detected our first two high (S/N), short timescale microlensing events. Both were filtered out from $4 \cdot 10^6$ pixel light curves using a variety of selection criteria which ensure that we did not confuse real microlensing with other variable sources like Mira stars. We therefore only considered well-sampled events with timescales of $1\,\mathrm{d} < \mathrm{t_{fwhm}} < 20\,\mathrm{d}$, high amplitude, and low χ^2 of the microlensing fit.The two-color photometry (R, I) shows that the events are achromatic and that giant stars with colors of $(R{-}I) \approx 1.1\,\mathrm{mag}$ in the bulge of M31 have been lensed. The most likely magnifications are 70 and 11, which are obtained for giant luminosities of $\mathcal{M}_I = -2.5\,\mathrm{mag}$.

Both lensing events lasted for only a few days (t_{fwhm} of 1.4 d and 5 d). The event GL1 is likely identical with PA-00-S3 reported by the POINT-AGAPE project.

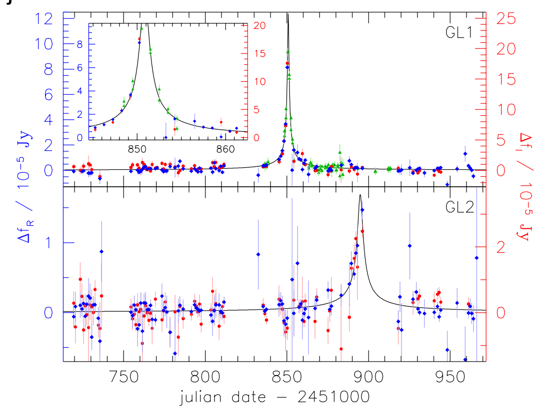

Fig. 2 Light curves of GL1 (upper panel) and GL2 (lower panel). The I-band light curve (red symbols, right axis) is scaled to the R-band light curve (blue symbols, left axis).

Mass estimates

Assuming the source to be a red giant with $\mathcal{M}_I = -2.5\,\mathrm{mag}$ we calculate the probability $p(M, t_{\mathrm{E}})$ that a microlensing event of observed timescale t_{E} can be produced by a lens of the mass M. The results are shown in Fig. 3. For M31 halo lenses the most probable masses are 0.08 $M_\odot$ for GL1 and 0.02 $M_\odot$ for GL2. Taking these most likely halo lens masses, the ratio of the probabilities that the lenses are in the halo (assuming a 100% MACHO fraction) relative to bulge and disk $p_{\mathrm{halo}}/(p_{\mathrm{bulge}}{+}p_{\mathrm{disk}})$ is 1.6 for GL1 and 3.3 for GL2. It is therefore likely that lenses residing in the halo of M31 caused the events in both cases.

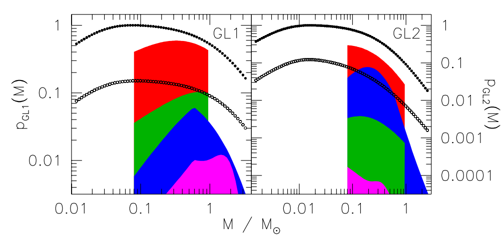

Fig. 3 Mass probability for GL1 (left) and GL2 (right) for lens-source configurations: halo-bulge (filled), halo-disk (open circles), bulge-bulge (red), bulge-disk (green), disk-bulge (blue), disk-disk (magenta).The maximum of each curve is scaled to reflect the total probability of a respective lens-source event relative to the case of a halo-bulge lensing event with the most probable MACHO mass.

References:

Riffeser et. al. (2003) ApJ 599L, p. 17
Gössl, C. A., Riffeser, A. (2002) A&A 381, p. 1095
Riffeser et. al. (2001), A&A 379, p. 362

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