Dark Matter in Galaxies
IAU Symposium, Vol. 220, 2004
S.D. Ryder, D.J. Pisano, M.A. Walker, and K.C. Freeman, eds.

The EROS2 Microlensing Study of the Galaxy

Clarisse Hamadache

CEA, DSM/DAPNIA/SPP, F-91191 Gif-sur-Yvette Cedex, France

Abstract. The latest results of the EROS2 experiment are presented. The search for gravitational microlensing events toward the Galactic Center and toward the Magellanic Clouds yielded an optical depth $\tau_{bulge} = 0.94 \pm 0.29 \times 10^{-6}$, and a strong limit, combining all EROS analyses, on the composition of the halo. Less than 25% of a standard halo can be composed of MACHOs with a mass range $[10^{-7}, 1]\,M_\odot$ at the 95% C.L.

EROS (Expérience de Recherche d'Objets Sombres) is a survey looking for microlensing phenomena. The temporary apparent brightening of distant stars in the Magellanic Clouds and toward the Galactic Center (GC) is used to study respectively the existence of MACHOs (dark halo objets) and Galactic structure. The probability of a star being magnified more than 34% is called τ, the optical depth. This is expected to be small $\sim 10^{-6}$ toward the GC and at most 0.5×10^{-6} toward the LMC, if the halo is composed of compact objects.

EROS2 uses the dedicated 1-m MARLY telescope, at the European Southern Observatory at La Silla, Chile. There are simultaneous observations in 2 wide-bands, red (760 nm) and blue (560 nm), with a dichroic beam splitter and 2 cameras, each with eight 2K×2K CCDs ($1.4^o \times 0.7^o$).

The four directions of observation are the Small and Large Magellanic Clouds ($10\,\mathrm{deg}^2 + 88\,\mathrm{deg}^2$), the Galactic Center ($82\,\mathrm{deg}^2$) and the Spiral Arms ($28\,\mathrm{deg}^2$). They were observed from 1996 until 2003.

The pipeline used to analyse EROS2 data is based on PSF-fitting techniques. A catalog is made (50×10^6 stars in the Galactic Center), and each catalog star is monitored: its flux is measured by PSF-fitting photometry on CCD frames, with a sampling time of 2–3 days. The lightcurves are analysed, to recognize a signal corresponding to the theorical magnification curve of a microlensing event.

The first estimate of EROS2 optical depth to microlensing toward the Galactic Center is based on the analysis of 15 contiguous fields centered on ($l = 1^\circ, b = -39^\circ$) and containing $N_* = 1.42 \times 10^6$ clump-giant stars monitored between mid-July 1996 and May 31, 1999. This bulge program was specifically designed to select events with bright stars as sources to avoid blending problems.

A first set of selection criteria yielded 33 candidates. We then selected candidates with a clump giant source (in the bulge, with a known distance). We rejected candidates with < 34% variation (risk of variable star contamination). This leaves 16 microlensing candidates.

Finally, we find $\tau_{bulge} = 0.94 \pm 0.29 \times 10^{-6}$ (Afonso et al. 2003a). This is lower (2–3 times less) than other determinations by the MACHO and MOA

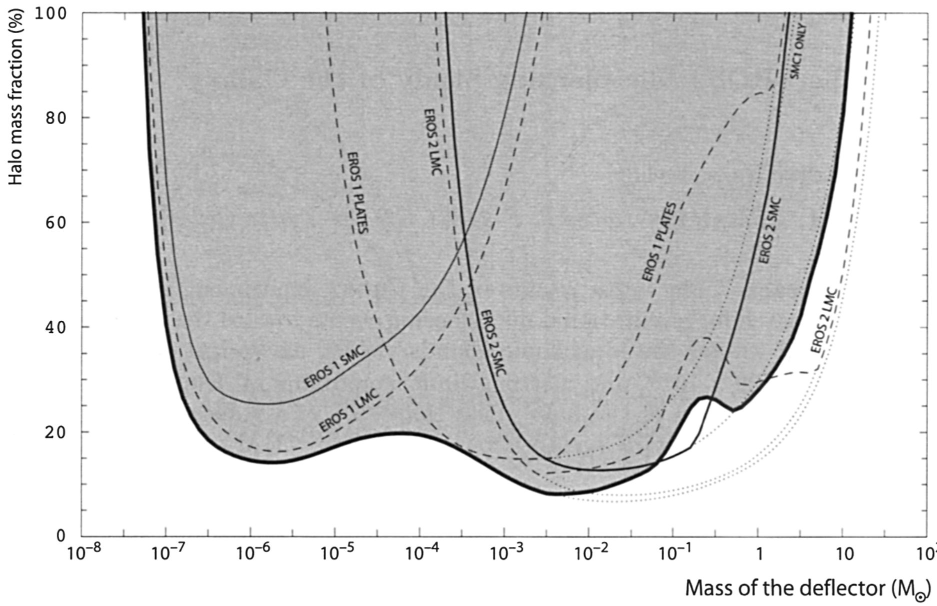

Figure 1. Exclusion diagram at 95% CL for a standard halo model. It combines results of all EROS analyses.

groups (Alcock et al. 2000; Sumi et al. 2003) and is in agreement with the Bissantz & Gerhard model (2002) (1.4×10^{-6}).

For the future we will obtain more precise results. The photometry for the full EROS2 GC data (6 years, 50×10^6 stars) is now complete. Analysis is under way. A few hundred candidates are expected in total (including ~ 100 with a bulge clump giant source). The chosen fields allow us to study the spatial distribution of microlenses (l and b variation). We will look for exotic events due to, for example, binary lenses.

The search toward the LMC and the SMC is sensitive to time scales between a few days and around 300 days corresponding to halo objects in the mass range $[2 \times 10^{-4}, 10]\,M_\odot$. The last result combining all EROS analyses (Afonso et al. 2003b), the limit at 95% C.L. on the fraction of the halo composed of MACHOs, is plotted in Figure 1. It confirms the fact that the halo cannot be entirely composed of MACHOs in this mass range.

References

Afonso, C. et al. 2003a, A&A, 404, 145

Afonso, C. et al. 2003b, A&A, 400, 951

Alcock, C. et al. 2000, ApJ, 541, 734

Bissantz, N., & Gerhard, O. 2002, MNRAS, 330, 591

Sumi, T., et al. 2003, ApJ, 591, 204

https://doi.org/10.1017/S0074180900183007 Published online by Cambridge University Press