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VVV Microlensing events in the far side of the Milky Way

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Abstract. In order to study the most reddened areas of the Milky Way we used near-IR data from the VVV Survey. For the first time, the VISTA telescope allows us to observe the mid-plane through the Galactic bulge and study the disk in the other side of the Milky Way. Motivated by the detection of hundreds of microlensing events in the inner regions of the Galaxy, we propose three new configurations of microlensing events, placing the sources in the far-disk and the lenses in the far-disk/bulge/near-disk. These new configurations will change the usual way to interpret the timescale distributions due to the different populations along the line of sight, that exhibit varied transverse velocities and relative distances.

Keywords. Galaxy: bulge, Galaxy: structure, gravitational lensing

1. The VVV Survey Beyond the Bulge

The near-IR data provided by the VVV Survey Minniti *et al.* (2010) during 5 years of observations (2010 – 2015) allow us to study the variability in the most obscured areas of the Galaxy. Many catalogs of variable stars have been published in order to complete the census, reaching for the first time the very center of the Milky Way. Among other kinds of variability, we studied the microlensing events in the plane of the Galaxy. The final sample is published in Navarro *et al.* (2017) and Navarro *et al.* (2018). Surprisingly, the VVV survey turns out to be one of the most efficient microlensing experiments to date. With only 200 nights of observations we have discovered almost one thousand events, this is the equivalent of producing about 5 events/night. This is mainly because the VVV survey is so deep that allows us to explore all the way through the plane of the Milky Way, reaching beyond the bulge.

The microlensing surveys such as OGLE (Udalski *et al.* (1993)) and MOA (Bond *et al.* (2001)) detected thousands of microlensing events in the bulge using optical band- passes. The subsequent analysis of the catalogs published by these groups traditionally include three configurations of microlensing events depending on the distributions of the sources and lenses along the line of sight: bulge-bulge, bulge-disk and disk-disk microlensing events, respectively. For each of them one can assume different values for the transverse

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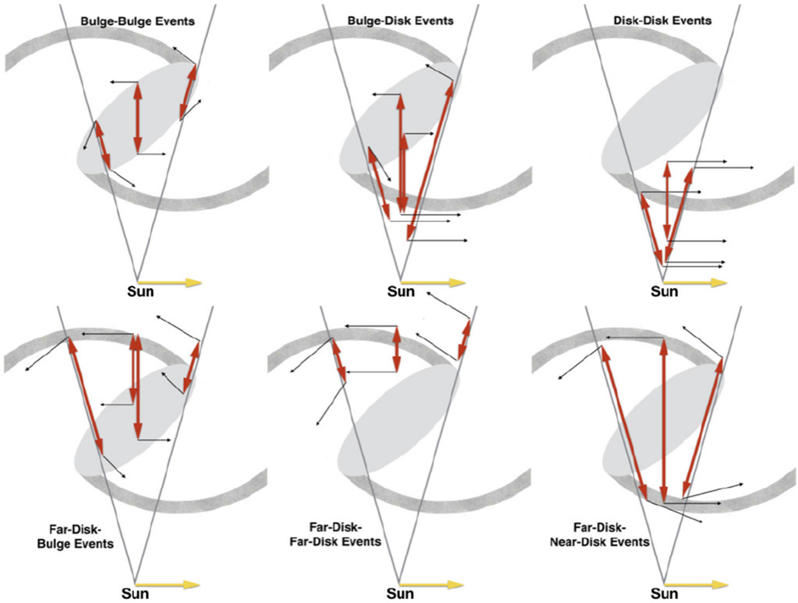

Figure 1. Galactic microlensing families as defined in the text. The graphs show a face-on view of the Milky way, with the central oval depicting the Galactic bulge, and the position of the Sun indicated at the bottom. For each case, we show schematic examples of the microlensing events in three different directions: at the extreme positive longitudes ($l = 10$ deg), in the direction of the Galactic minor axis ($l = 0$ deg), and at the extreme negative longitudes ($l = -10$ deg). The double headed red arrows show the relative locations of the sources (always on top), and lenses (always at the bottom). The thin black arrows show the expected direction of the velocities of the microlensing sources and lenses. The Sun shares the motion of the nearby disk stars.

velocities and relative distances. However, in the specific case where we use deep VISTA near-IR PSF photometry it is necessary to include the contribution from the far-disk (the disk located behind the bulge) in the configuration. In this context, the new configurations proposed along with the traditional ones are illustrated in Fig. 1. As an example, the United Kingdom Infrared Telescope Survey Telescope (UKIRT, Shvartzvald *et al.* (2017)) that is observing towards the central parts of the Galaxy with a higher cadence, recently published an event with the source in the far disk (Shvartzvald *et al.* (2018)).

There are a few techniques proposed in order to select the sources located in the far disk. The near-IR Color-Magnitude diagram can be used to separate the far sources. For a proper analysis it is important to correct for the extreme differential reddening. Red clump sources are useful distance indicators, that can now be well calibrated with Gaia DR2 data (Gaia Collaboration *et al.* (2018)). Recent studies of the VVV color-magnitude diagrams show more than one red clump along the line of sight (Gonzalez *et al.* (2018); Minniti *et al.* (2018)), with the faintest probably due to the population of stars in the far disk of the Galaxy. Using this analysis, we can select the sources located in the faint red clump as good candidates for the far-side sources of microlensing events.

References

Bond, I. A., Abe, F., Dodd, R. J., *et al.* 2001, *MNRAS*, 327, 868
Gaia Collaboration, Babusiaux, C., van Leeuwen, F., *et al.* 2018, *A&A*, 616, 10
Gonzalez, O. A., Minniti, D., Valenti, E., *et al.* 2018, *MNRAS*, 481, L130
Minniti D., Lucas, P. W., Emerson, J., *et al.* 2010, *New Astron.*, 15, 433

https://doi.org/10.1017/S174392131900872X Published online by Cambridge University Press

Minniti D., Saito, S. K., Gonzalez, O. A., *et al.* 2018, *A&A*, 616, A26
Navarro, M. G., Minniti, D. & Contreras Ramos, R. 2017, *ApJ* (Letters), 851,13
Navarro, M. G., Minniti, D., & Contreras Ramos, R. 2018, *ApJ* (Letters), 865, 5
Shvartzvald, Y., Bryden, G., Gould, A., *et al.* 2017, *MNRAS*, 457, 4089
Shvartzvald, Y., Novati, S. C., Gaudi, B. S., *et al.* 2018, *ApJ* (Letters), 857, 8
Udalski, A., Szymanski, M., Kaluzny, J., *et al.* 1993, *AcA*, 43, 289

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