Estimatig Gaia's performance for O stars in the Outer Galactic Plane using Herschel data

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Despite the rareness of O-stars, they dictate much of the shape of the interstellar matter in the Milky Way due to their high luminosities and stellar winds. O-stars are often surrounded by shells and bubbles, in which star formation might or might not continue.

Particularly, the effect of Galactic shear on the star formation in shells around O stars is the target of our future study. This effect can be isolated at large Galactocentric distances, in low density shells around luminous stars. To estimate the shear, and other physical properties, accurate distances toward the O stars are necessary, and that is the topic of this poster.

1. **Gaia will be able to provide accurate (5σ) astrometry for O stars in the Outer Galaxy up to distances of about 4 kpc.**
2. **Herschel Hi-GAL maps show that the Galactic plane in the Outer Galaxy has largely Av≤15 mag.**
3. **Gaia Spectral type determination and its sensitivity limit of G≤20 mag will find many new, farther O stars.**

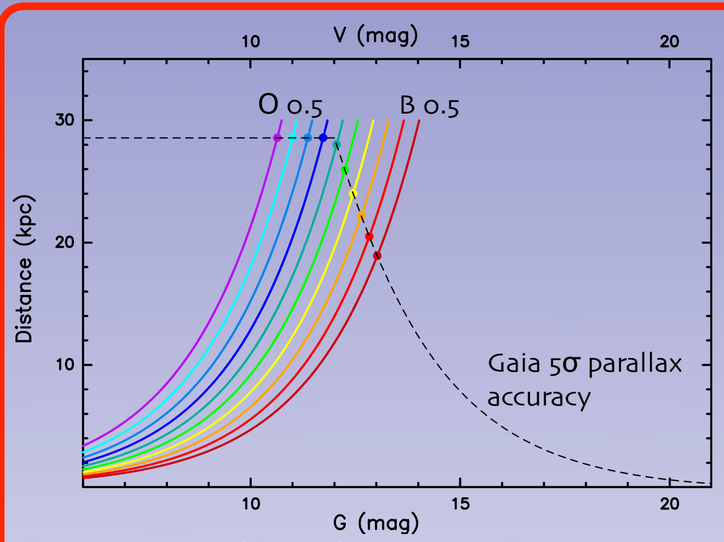

Fig 1. Magnitudes of O-dwarf subtypes with T_{eff} 50-27.5 kK (colors) versus the Gaia instrument 5σ parallax accuracy predicted for V-I=-0.29 mag (typical for O dwarfs) given Av=omag. The V and G magnitude relation changes with increasing extinction (G<V when Av>0).

ESA's Gaia satellite will measure the parallaxes of 1 billion stars with G-magnitudes (centered on 673 nm, FWHM=440 nm) brighter than 20 mag. Estimating Gaia's parallax performance per stellar type is done by finding the intersection of the instrument accuracy and the stellar flux based on TLUSTY (Lanz & Hubeny 2003) model atmospheres (Fig 1). Gaia parallaxes in the Galactic plane are strongly limited by dust extinction. Though, for A_V≤15 mag Gaia parallaxes can deliver accurate astrometry for stars with d≤4 kpc in the Galactic plane (Fig 2).
But, what are the visual extinctions in the outer Galactic plane? The Herschel Infrared Galactic plane survey (Molinari et al. 2010) might have the best possible answer..

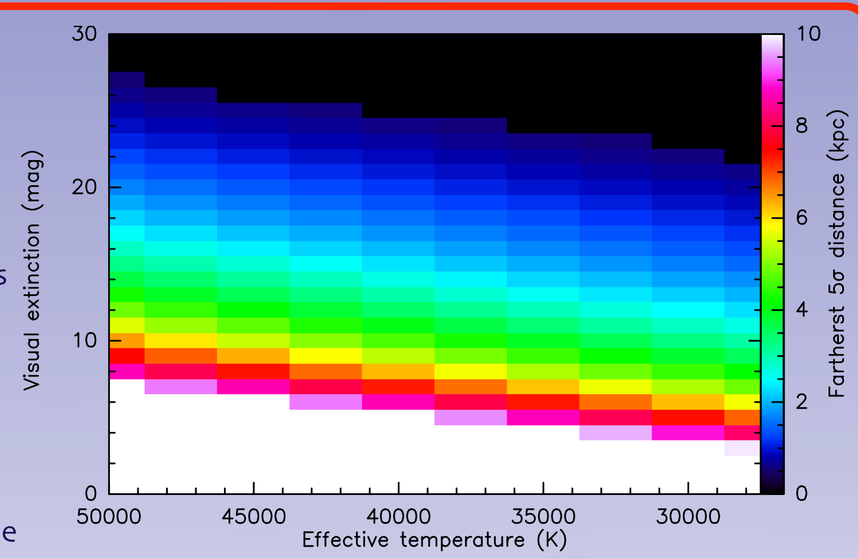

Fig 2. Farthest Gaia 5σ distance for a range of T_{eff} (O-dwarf substypes) and visual extinction, given the observable Gaia magnitude range 6<G<20 mag.

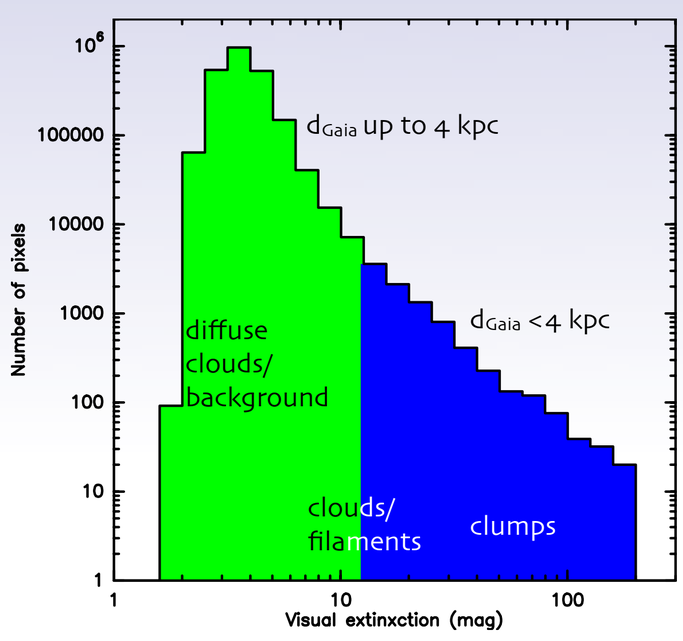

Fig 4. Histogram of the A_V distribution in Fig.3

The five-wavelength Herschel maps can be translated, by fitting a modified black body model to the SED, to hydrogen column density or visual extinction maps. The A_V map between l105 and l115 (Fig 3) shows that the average background is but 2-4 mag, while clouds and clumps have 5-20 mag and >20 mag, respectively. By far, most of the map consists of pixels with A_V<15 mag (Fig.4). Due to their powerful winds, O stars are usually not anymore embedded in their natal high-density (high exinction) environment, though they can be still in the cloud, nearby the dense star-forming regions (Fig 3). Unless the extinction is much higher on smaller angular scales than explored by the Herschel maps, it appears that Gaia will be excellent to study O stars in the Perseus Arm, and might even reach some stars in the Outer Arm. A more detailed study of all the Outer Galaxy column density maps is underway.

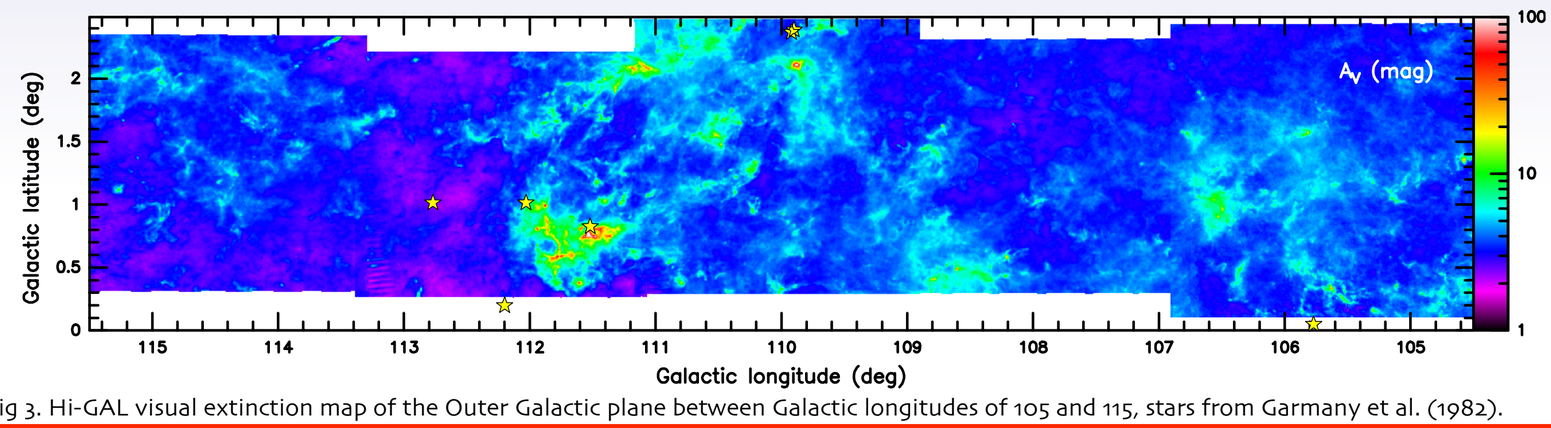

Fig 3. Hi-GAL visual extinction map of the Outer Galactic plane between Galactic longitudes of 105 and 115, stars from Garmany et al. (1982).

Existing catalogs give about hundred O-stars in the Outer Galactic plane. However, these catalogs have a strong flux limitation at 10-12 V mag (Fig 5). Apart from the two mirrors for accurate position measurements, the Gaia satellite also has a Radial Velocity Spectrometer and a Blue and Red Spectrophotometer on board to measure the stellar radial velocities and colors, respectively.
Using these instruments, also the spectral type and the extinction can be identified. Bailer-Jones et al. (2013) showed that using a special treatment for hot stars, O-star classification will be possible for G≤15mag. Hence, Gaia is bound to discover many new, more distant O-stars!

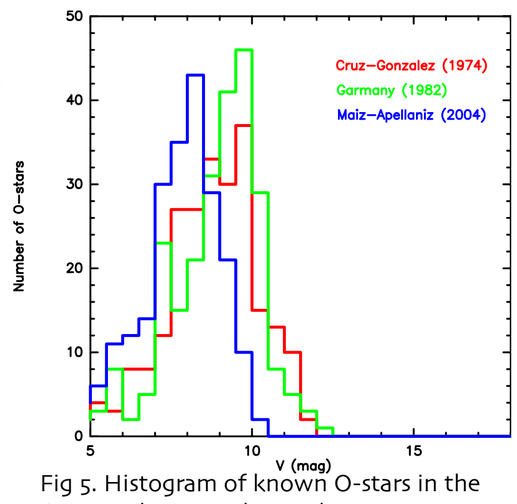

Fig 5. Histogram of known O-stars in the Outer Galaxt (90<l<270 degree).

References
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More information about the Gaia instruments, the parallax uncertainty estimation, and the conversion to G magnitudes can be found on http://www.cosmos.esa.int/web/gaia