Structure and evolution of the inner Milky Way galaxy

results from ISOGAL

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Abstract.

The DENIS/ISOGAL near/mid-IR survey of the Milky Way for the first time probes stellar populations in the innermost obscured regions of our galaxy. Ages, metallicities and extinction-corrected luminosities are derived for these stars individually. An old metal-rich population dominates in the inner galactic Bulge, but there are also indications for the presence of a younger population. The inner Bulge has a tri-axial shape, as traced by depth effects on the observed luminosity distributions.

Keywords: Milky Way, Bulge, Galaxy: Structure, Galaxy: Evolution, Stellar Populations, AGB stars, RGB stars, Infrared, Extinction

1. Introduction

Attempts to understand the evolution of galaxies by studies of their stellar populations as a function of redshift are limited by sensitivity and angular resolution. Our nearest galaxy, the Milky Way, has the potential to provide many important clues on the evolution of galaxies: ages and metallicities may be measured for individual stars, and the spatial and kinematic distributions of the different stellar populations may be observed. For the innermost parts of the Milky Way, however, where most stellar light and mass are and where most activity is happening, this has not yet been the case. Due to the location of the Sun in the galactic plane, our view of the central few hundred pc of the galactic Bulge and the inner few kpc of the galactic disk is obscured by tens of magnitudes extinction at visual wavelengths.

Advances in IR instrumentation have recently led to several near- and mid-IR surveys of the Milky Way, both from the ground (DENIS, 2MASS, TMGS) and from space (ISOGAL, MSX). These probe large numbers of stars situated deep within the obscured regions of the inner Bulge, for the first time allowing the study of the stellar populations in the core of our own galaxy. The catalogue of IR point sources from the DENIS/ISOGAL 0.8—15 μm survey (Omont et al., 1999) is used here to derive the ages, metallicities, luminosities and extinction for ~ 3×10⁴ individual stars in the inner galactic Bulge, and the implications for the structure and evolution of the galactic Bulge are discussed.
2. Data and methods

The ISOGAL 7 and 15 µm images of typically 15′ × 15′ and pixel scales of 3″ or 6″ sample the Milky Way especially well for −10° < l_II < +10° and −2° ≤ b_II ≤ +2°, which is the region studied here. Photometry for point sources is complemented by DENIS I,J and K_s-band photometry. An example of an IR colour-magnitude diagram for two fields is given in Fig. 1, together with an isochrone for a 10 Gyr old population of solar metallicity (Bertelli et al., 1994). The red colours of the stars are predominantly due to severe interstellar extinction.

The age, metallicity and extinction (adopting Mathis, 1990) are derived for each individual star by comparing its location with respect to isochrones (Bertelli et al., 1994) in various IR colour-magnitude diagrams, after proper computation of bolometric corrections. For stars without sufficient photometry to solve for all three variables, the extinction is assigned as derived for neighbouring stars. The luminosity and effective temperature are obtained for free.
3. Stellar populations

As a first result, the luminosity distribution of the stars is plotted in Fig. 2. The Asymptotic Giant Branch (AGB) is detected even in the obscured galactic core region. In most regions the Red Giant Branch (RGB) is detected down to a few $10^2 \, L_\odot$. The derived effective temperatures are generally $T_{\text{eff}} \sim 2500$ to $4000$ K, confirming the red giant nature of most of the stars. A few hundred bright mid-IR sources have been identified that are interpreted as mass-losing AGB stars, some of which are associated with OH maser emission.

4. Ages and metallicities

The metallicity distribution covers the wide range of $[M/H] \in [-1.7, 0.4]$, although the higher metallicity stars amongst these are more common. There is only a very marginal indication for a negative metallicity gradient over the inner $\sim 1$ kpc from the Galactic Centre.
The dominant population of the inner Bulge is old, $t \gtrsim 10$ Gyr, but there is a significant intermediate population, $t \sim 1$ Gyr, and possibly an even younger population of $t \lesssim 100$ Myr too. The age distribution is fairly uniform over the inner Bulge, although the average age of the youngest component may slightly increase outwards.

This suggests that in the galactic Bulge star formation did not switch off completely after the first generations of stars were born and that we now see as the old, metal-rich population. Instead, the intermediate-age population of AGB stars implies on-going star formation over most of the galactic history, while the young population might represent a recent epoch of enhanced star formation, possibly due to a minor merger event.

5. Three-dimensional structure of the inner galactic Bulge

The extinction-corrected luminosity function shows a clear asymmetry in the galactic plane at either side of the Galactic Centre: it is brighter at $l_\Pi \sim -6^\circ$ than at $l_\Pi \sim +6^\circ$. This can be understood in terms of differential depth effects, if the inner Bulge has a tri-axial shape on a radial scale of $R \sim 1.4$ kpc under an angle $i \sim 53^\circ$, with the near side at negative longitude. This geometry is much alike that proposed for the larger scale Bar, which is, however, rather a disk phenomenon. The origin of the tri-axiality of the Bulge might be related to the suggested recent star formation.

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References

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