Galactic Dynamics in the Era of Large Surveys
Proceedings IAU Symposium No. 353, 2019
M. Valluri & J. A. Sellwood, eds.

doi:10.1017/S1743921319008111

Stellar populations in the BAaDE survey

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Abstract. The BAaDE (Bulge Asymmetries and Dynamical Evolution) project is an SiO maser survey of the Galactic Plane. About 19,000 sources have been observed at 43 GHz with the VLA, and the production of spectra for each of these sources is well underway. The primary goal of the project is to collect line-of-sight velocities for all the detected masers in the sample to probe Galactic dynamics. With an expected detection rate of over 60% we should collect over 11,000 velocities to probe the Galactic potential. The survey is also a large sample of infrared sources to explore the different evolved stellar populations within the Milky Way. So far we discern three distinct groups in the BAaDE sample: the main group containing oxygen-rich, evolved stars with a high SiO maser detection rate, a much smaller population of carbon-rich evolved stars, and finally a group of likely young stellar objects with no maser emission. These populations are separated using 2MASS and MSX color-color diagrams, and we find a particularly useful cut between the young and evolved objects using the MSX [D] − [E] color. Identification of these populations will isolate BAaDE's evolved star sample, and will more tightly define the region in IR color-color diagrams where SiO masers occur yielding a better understanding of these kinematical probes. Using our color-divisions we can also study the distribution of each of the populations within the Galactic Plane.

Keywords. Galaxy: stellar content, stars: AGB and post-AGB, masers

1. Introduction

BAaDE (Bulge Asymmetries and Dynamical Evolution) is an SiO maser survey of $\sim$ 28,000 Asymptotic Giant Branch (AGB) stars in the Galactic Plane. The position and line-of-sight velocity derived from maser lines of each source will be used to study Galactic dynamics. About 13,000 sources have been analyzed so far. BAaDE survey targets are chosen from the Mid-course Space eXperiment (MSX) catalogue based on their IR-color (Sjouwerman *et al.* 2009). MSX covered four-bands with enough sensitivity for astronomical studies: [A], [C], [D], and [E] bands corresponding to center wavelengths of 8, 12, 14, and 21μm, respectively. From the MSX PSC 2.3 (Egan *et al.* 2003), sources which match the IR-color of thin-shelled AGBs are considered likely to host SiO masers (van der Veen & Habing 1988) and are then surveyed with either the VLA or ALMA depending on declination. The data are then calibrated to check for radio frequency SiO maser (and any other) emission, and finally line-of-sight velocities are extracted for SiO-detected sources. Because these masers are detected at radio frequencies, they are not obscured by dust and can even be detected in the Plane and Bulge, probing areas that have previously been difficult to probe via optical surveys.

The initial selection of BAaDE sources included not only O-AGB (Oxygen-rich) sources (our dynamical probes) but was also unintentionally contaminated by a small populations of C-AGBs (Carbon-rich) and young stellar objects (YSOs). YSO sources especially will

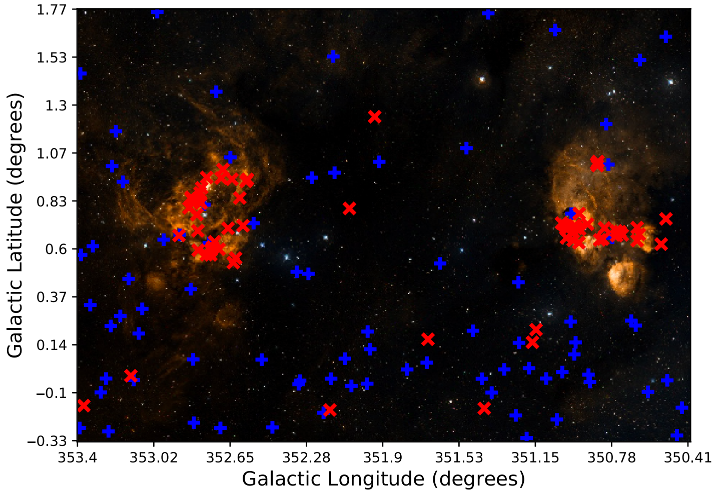

Figure 1. Color selected YSOs (red x's) and O-AGBs (blue +'s) on a Digital Sky Survey backdrop. The sources identified as YSOs are clumped in and around molecular clouds, which supports their identification as YSOs.

not probe the dynamics of the same population as AGBs. Hence we must identify and isolate these different populations. Our primary tools for identifying separate populations in the sample are: IR-color, SiO maser emission, and Galactic distribution.

2. Results: O-AGB, C-AGB, and YSO populations

The YSOs are separable from the AGBs using only the MSX [D] − [E] color, with sources at [D] − [E] > 1.35 being mostly YSOs. The YSOs show a low detection rate of SiO masers (6%) as compared to the AGBs (70%), as well as a high rate of CS thermal detections in the ALMA data.

We cannot separate C- and O-AGBs in purely MSX colors and therefore cross-match with the 2MASS catalogue. We find a clear division between C- and O-AGBs when including the $[K_s]$ magnitude, where C-AGBs are found at $[K_s] - [A] > 6([A] - [E]) - 3$. Both the division scheme for YSOs/AGBs and the division between C/O-AGBs match similar divisions found in the sample in Lumsden *et al.* (2002).

Applying our defined color-cuts, we can examine the Galactic distributions of our three populations. The sources identified as YSOs lie close to the Plane and are clumped around molecular clouds (Fig. 1); this supports their identification as YSOs. The C- and O-AGBs both span a wider range of latitudes than the YSOs, and the O-AGBs are more concentrated towards $l = 0$ than the C-AGBs, further indicating our identifications are viable.

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https://doi.org/10.1017/S1743921319008111 Published online by Cambridge University Press