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Anyone out there? Post-AGB stars in the Galactic halo

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To date, only a limited number of post-AGB stars are known throughout the Milky Way. If we look at possible members of the old Galactic populations - halo and thick disc - numbers get even smaller with only a handful of candidates known plus a small number of PNe. Most known post-AGB stars were selected from IR surveys, and thus a bias against slowly evolving low mass post-AGB stars could play a role. Simple back-of-the-envelope calculations and more-detailed simulations of the populations indicate that sizable samples of thick disc and Population II post-AGBs should exist and be detected in colour surveys like Palomar-Green and SDSS. If this discrepancy is real and not caused by selection effects, this would indicate that only a minority of thick disc/halo stars are evolving along the post-AGB channel. We report from an ongoing project to systematically identify post-AGB stars at high Galactic latitude. We compare results from a study by Saffer et al. (1997) of a complete sample selected from the Palomar Green survey with predicted numbers. We also performed a systematic search of the SDSS database (DR7) for possible post-AGB candidates. Only one(!) possible post-AGB candidate was found in an analysis of 21,031 blue SDSS spectra. We discuss and explore observational biases which may cause the result. If found to be truly representative of the halo and thick disc population this would indicate that the vast majority of Population II stars do not follow a standard evolution path. One possible alternative would be evolution through the blue/extreme horizontal branch bypassing the AGB.

Anyone out there? Post-AGB stars in the Galactic halo

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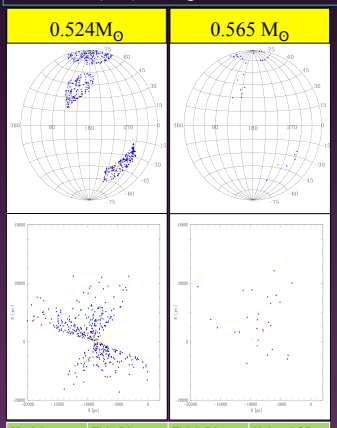
Abstract

To date, only a limited number of post-AGB stars are known throughout the Milky Way. If we look at possible members of the old galactic populations - halo and thick disc - numbers get even smaller with only a handful of candidates known plus a small number of PNe. We report from an ongoing project to systematically identify post-AGB stars at high galactic latitude. We compare results from a study by Saffer et al. (1997) of a complete sample selected from the PG survey with predicted numbers. We also performed a systematic search of the SDSS spectroscopic database (DR7) for possible post-AGB candidates. Only one(!) possible post-AGB candidate was found in an analysis of 21,031 blue SDSS spectra. We discuss and explore observational biases which may cause the result. If found to be truly representative of the halo and thick disc population this would indicate that the vast majority of pop. II stars does not follow a standard evolution path. One possible alternative would be evolution through the blue/extreme horizontal branch bypassing the AGB straight to the white dwarf (WD) cooling tracks.



Introduction

Most known post-AGB stars were selected from IR surveys, and thus a bias against slowly evolving low mass post-AGB stars could play a role. Simple back of the envelope calculations and more detailed simulations of the populations indicate that sizable samples of thick disc and pop. II post-AGBs should exist and be detected in colour surveys like Palomar-Green (PG) and Sloan Digital Sky Survey (SDSS). If this discrepancy is real and not caused by selection effects, this would indicate that only a minority of thick disc/halo stars is evolving along the post-AGB channel. Drilling & Schönberner (1985) observe that only 0.2-3% of stars which evolve off the main sequence will not become post-AGBs. As this may be biased to the local sample we have used a model population synthesis model to determine whether we expect to find post-AGB stars at high galactic latitudes.

Simulated Populations

Adapting Napiwotzki's (2009) Monte Carlo WD simulated population using a standard structure of our galaxy and calibrated using observations of the local WD sample we produce a synthetic post-AGB population. For each star a location, metallicity, radial velocity (therefore, population group) and mass using a Salpeter initial mass function is simulated. The stars evolve individually to the tip of AGB using the Padova group evolutionary tracks. Finally, post-AGB tracks of various masses (Schönberner, 1981 and Blöcker, 1995) are applied to the evolved sample and their current evolutionary phase determined.

Figure 1. A simulated sample of three complete regions of the PG survey followed-up and studied by Saffer et al. (1997) for different post-AGB/WD mass. The top plots are in galactic coordinates and the bottom in galactic X and Z vectors. The red, blue and black dots represent thin disc, thick disc and halo post-AGBs respectively. The regions are limited by coordinates, brightness limit (B_{PG} < 14.7), and an initial colour cut (U-B ≤ -0.46). The latter two criteria giving a distance and temperature limit, respectively. We normalise the simulated local WD sample with the observed WD density of Holberg et al. (2008) and the corrected numbers are shown in the table. However, even for the largest investigated post-AGB mass there are significantly more (halo) post-AGBs predicted than are found in the observed survey.

Model	Thin Disc pAGBs	Thick Disc pAGBs	Halo pAGBs
0.524	11	37	160
0.546	12	28	59
0.565	0	1	13
0.605	0	0	16
Observed	0	0	2(?)

Table. Predicted post-AGB populations for a given mass.

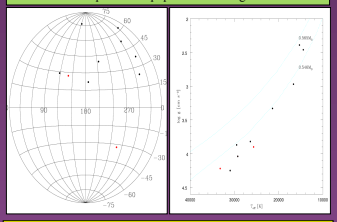


Figure 2 (left). The Saffer sample of post-AGB candidates. The two red dots are the remaining candidates in the complete sample.
Figure 3 (right). The complete Saffer sample on a T_{eff}-logg diagram showing the post-AGB tracks of Schönberner(1981).

Observed Population

PG – In the Saffer et al. (1997) sample there are ten post-AGB candidates (Fig. 2). High resolution follow-up spectroscopy had been carried out on all three of the objects in the complete sample. PG 1212+369 was ruled out as a candidate due to its likely close binary interaction in its earlier evolution. This left PG 1243+275 and PG 2120+062 as the only possible candidates. Moreover, the T_{eff}-logg diagram (Fig. 3) suggests that all the candidate objects are low mass as they lie below the 0.546M$_\odot$ track. This is consistent with one might expect for an older population but the simulated numbers increase for lower mass post-AGBs.

SDSS – With the depth of the SDSS and the large number of spectra taken we expected to find some post-AGB stars particularly with our large predicted number. We selected only SDSS spectra with a 'blueish' photometry. Balmer lines are fitted to all of the spectra but found only one strong candidate, SDSS J145817.52+022806.6 (fit shown in Fig. 4). The poorer fitting Helium lines in the wings of the Balmer line core are observed in post-AGB and pEHB stars. A large fraction of the other spectra are extragalactic objects. For the time being we cannot rule out that the lack of post-AGBs from the spectra sample could be a follow-up selection bias.

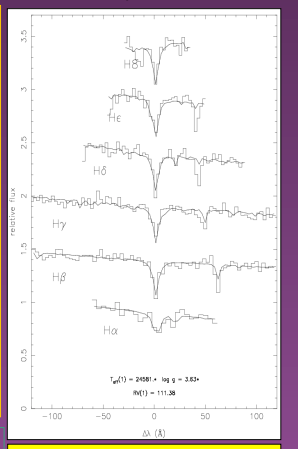


Figure 4. Balmer line spectra for our only post-AGB candidate in SDSS, **SDSS J145817.52 +022806.6**.

Discussion & Conclusions

The massive discrepancy between the observed and predicted post-AGB populations suggest the simulated evolution is not a good representation of halo post-AGBs. The PG complete sample is well studied and the initial SDSS spectra agree that these objects appear to be rare. Why do the simulations produce so many post-AGBs, what is an alternative evolutionary channel and has this been observed before? Brown et al. (2008) find a dearth of post-AGBs in M32 an elliptical which has a similar environment as our galactic halo. Possible solutions are that the progenitor envelope mass is too low for the stars to ascend the AGB, instead evolving via the horizontal branch. This implies a significant decrease in the galactic percentage of stars which evolve through the AGB phase. Alternatively, they could evolve quicker across the post-AGB track, however, this solution is unlikely as this would be more likely to produce a PN.

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