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BRITE stars on the AGB

T. Lebzelter[1], J. Hron[1]

[1] Institut für Astronomie, Türkenschanzstrasse 17, 1180 Vienna, Austria

Abstract

In this paper we evaluate the potential of the BRITE mission for investigations in the field of AGB stars.

Introduction

The Asymptotic Giant Branch (AGB) phase is a decisive step in final stellar evolution for stars of low and intermediate mass. It is characterized by low surface temperatures, huge stellar radii, high luminosity, variability of various origins and pronounced mass loss. These stars play an important role in the production of heavy elements and in the enrichment of the interstellar medium with these elements by effective mass loss. Their circumstellar environments are also the site of the production and growth of solid particles (dust). The complex nature of AGB stars requires several observational approaches in a broad wavelength range from visual photometry to mm interferometry and laboratory studies, e.g. of solid particles. A comprehensive review on AGB stars can be found in Habing & Olofsson (2003) or Kerschbaum et al. (2007).

At a first glance we would expect that AGB variables provide perfect targets for BRITE as they are among the intrinsically most luminous stars and are significantly more numerous than blue supergiants. Unfortunately the possibilities and needs are in fact limited as revealed by a more detailed look on their characteristics.

AGB stars and BRITE

AGB stars are cool, dusty and very unstable. They are thus not that bright in V, while they are the most luminous stellar sources in the infrared sky. Due to the dominant role of molecular features in their spectra the flux is strongly dependent on wavelength, so that for a description of the origin and nature of any observed variability several narrow passbands would be the preferred tool (e.g. Wing 1992 and references therein).

Table 1: List of potential targets from the General Catalogue of Variable Stars (Kholopov et al. 1985-88). Variability classes: M...mira, SRV...semiregular variable, Lb...irregular variable.

GCVS Name	V_{max}	V_{min}	Spectral type	Variability class
λ Aqr	3.70	3.80	M2	Lb
R Car	3.90	10.50	M6/M7	M
o Cet	2.00	10.10	M5-M9	M
χ Cyg	3.30	14.20	S7,1	M
τ^4 Eri	3.57	3.72	M3/M4	Lb
μ Gem	2.75	3.02	M3	Lb
R Hya	3.50	10.90	M6/M7	M
σ Lib	3.20	3.46	M3/M4	SRV
R Lyr	3.88	5.00	M5	SRV
β Peg	2.31	2.74	M2	Lb
ρ Per	3.30	4.00	M3	SRV
L^2 Pup	2.60	6.20	M5	SRV

Variability of AGB stars is a phenomenon known since 400 years when the star o Cet (Mira) was discovered to be the first periodic variable star at all. The AGB variables are typically summarized in the class of long period variables, characterized by variability time scales from 30 to 1000 days and visual light amplitudes between 0.1 and 8 mag. Three subclasses were defined, namely miras (M), semiregular (SR) and irregular (L) variables, respectively. Recently, attempts can be seen to replace this old system of subclassification by a more meaningful classification according to the dominant pulsation mode (e.g. Wood 2000).

While the rather long time scales involved seem not to require a dense photometric coverage as provided by BRITE, the typical light amplitude limits the possibilities to study these stars with BRITE more severely. A typical mira with a light amplitude of several magnitudes becomes – at most – visible to BRITE only during a short phase around its maximum, most of the light cycle the star remains below the satellite's brightness limit. Miras are thus certainly not primary targets for BRITE. Table 1 gives a list of potential targets among the AGB stars applying a lower brightness limit of V =4 mag. Note that all miras and some of the SRVs are clearly below this limit during minimum light.

Semi- and irregular variables are certainly a more interesting group of stars for a study with BRITE. Typical light curves can be seen e.g. in Kerschbaum et al. (2001). A proper description of the variability behaviour, which is essential for a complete understanding of the origin of the instability, requires a continuous monitoring over a large number of light cycles (compare Lebzelter et al. 1995, Lebzelter & Kiss 2001). In this case the observing mode of BRITE can be extremely useful, filling also the seasonal gaps in photometric time series from automatic telescopes on the ground (Kerschbaum et al. 2001).

Another aspect of AGB star research may profit from BRITE. It is expected that only a few very large convective cells should cover the whole surface of an AGB star. Opposite to the small cells on the sun the rising and falling of these large cells should lead to clearly visible (up to 30 %), irregular brightness variations on time scales between 0.3 and 1.5 years. First 3D simulations (e.g. Freytag et al. 2002) give results comparable to the irregular light variations observed in red supergiants. Variability due to convective cells may also be hidden in the light change of AGB variables. A second indication for surface inhomogeneities that should become visible in a high precision, continuous study comes from the observed asymmetric shapes of planetary nebulae, the product of an AGB star's heavy mass loss. It is suspected that these asymmetries result from spots, deviations from spherical symmetry of the AGB star or binarity (e.g. Soker & Hadar 2002).

Conclusions

We find that AGB stars as representatives of the intrinsically bright stellar objects are interesting targets for BRITE. However, the number of possible targets is rather small, including only about 10 SRVs/Lbs with the current brightness limit (including the two bright red supergiants – variability class SRc – α Ori and α Sco). To improve the situation and to increase the scientific outcome of the mission in the field of AGB stars we would favour the use of a redder (e.g. R, I) and more narrow pass band for the observations.

For the science cases we find first that the typical timescales of SRVs do not necessarily require a high sampling rate or high photometric precision. In principle the required monitoring could also be done from the ground. For irregular variables with their variations occurring partly on shorter time scales and with smaller light amplitudes a monitoring with BRITE may resolve the origin of their irregularity. Furthermore, in all AGB stars asymmetries and convective cells at the surface may leave signatures detectable with high precision, long time photometry. A synergy with ground based parallel interferometric imaging, which typically goes for the brightest objects, too, can be expected. For all these aspects BRITE can contribute significantly to our knowledge of the late evolutionary stages of solar like stars. However, as mentioned above, it will be critical to achieve a time series with a length of at least the length of the variability period, i.e. a few ten to a few hundred days of continuous measurements (with only a few data points per day). Finally, the COROT mission, which also monitors a few AGB stars, may suggest further interesting aspects not considered up to now.

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