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THE TRANSITION PHASE FROM AGB STARS TO PNE AS SEEN BY CANARICAM

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RESUMEN

Exploramos las posibilidades de CanariCam, como uno de los instrumentos científicos de primera luz disponibles en el GTC, de mejorar nuestro conocimiento acerca de los procesos físicos que tienen lugar en la corta fase de transición que precede a la formación de una Nebulosa Planetaria (PN, en adelante). La capacidad de CanariCam de obtener tamto imágenes como espectroscopía en el infrarrojo medio se muestra como extremadamente potente y adecuada para el estudio de la evolución escondida de las estrellas AGB en su camino hasta convertirse en PNe.

ABSTRACT

We explore the possibilities of improving our knowledge of the physics of the short transition phase that precedes the formation of a planetary nebula (hereafter PN) with CanariCam as one of the first-light science instruments available on the GTC. Both the mid-infrared imaging and spectroscopic capabilities of CanariCam are shown to be extremely powerful and suited to studying the hidden evolution of AGB stars on their way to becoming PNe.

Key Words: **INFRARED: STARS — PLANETARY NEBULAE: GENERAL — STARS: AGB AND POST-AGB — STARS: CIRCUMSTELLAR MATTER**

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1. INTRODUCTION

Based on the analysis of a large sample of *ISO* SWS spectra of stars in the transition between the asymptotic giant branch (AGB) and the planetary nebula stage we have been able to propose an evolutionary scheme that nicely reproduces the temporal evolution of the infrared spectra in this short transition phase (García-Lario & Perea-Calderón, in preparation). Our acquired experience in the study of these objects in the spectral range from 2 to 45 mm with *ISO* gives us a clear idea of the extraordinary potential of CanariCam in this field.

2. THE CAPABILITIES OF CANARICAM

Identification of the mid-infrared counterparts (Imaging) The objects in this transition phase of the stellar evolution in most cases are invisible in the optical range. In the most extreme cases they do not even show any counterpart in the near infrared and their detection is possible only beyond 10 μm, where they can be extremely bright. Actually, these are the brightest objects in the sky in the mid infrared.

Determination of the source morphology (Imaging) With the help of CanariCam it will also be possible to determine whether the sources detected in the mid infrared show any kind of extended and complex morphology shedding light on the controversial issue of when the departure from spherical symmetry takes place during this short transition phase, which leads to the marked bipolar structures usually observed in evolved PNe.

Identification of the dominant chemistry (Spectroscopy) The spectral features detected in the mid infrared of objects evolving from the AGB to the PN stage are strongly dependent on the C/O ratio in the photosphere and in the circumstellar shell leading to the formation of completely different chemical compounds that can be easily detected in their spectra. Essentially, the objects can easily be classified as C-rich or O-rich depending on the observed dominant chemistry, which is found to be correlated with the mass of the progenitor star. In some cases, sources have been detected showing a mixed chemistry, which is interpreted as the consequence of the dredge-up of C-rich processed material to the surface of the star, which can eventually produce a switch to a C-rich dominant chemistry first in the photosphere and then in the dust-grains formed in the circumstellar shell. This is expected to happen preferentially in intermediate mass AGB stars.

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Based on our previous experience with the analysis of *ISO* data, we have proposed different evolutionary schemes for stars in this transition phase as a function of the progenitor mass. One of them, the high mass (4–8 $M_{\odot}$) O-rich sequence is shown as example in Figure 1. With CanariCam it would be possible to improve this analysis with deeper spectra of sources previously observed with *ISO* with a poor S/N ratio, and extend the analysis to a larger sample. covering a wide range of brightness and physical properties.

Determination of the evolutionary status (Spectroscopy) Through the analysis of the mid-infrared spectra of these transition objects it is also possible to determine with a high degree of accuracy the evolutionary status of the source. The information provided by the underlying continuum provides information on the temperature of the dust grains and the degree of obscuration produced by the circumstellar shell on the photospheric spectrum. On the other hand, the profiles observed in some of the solid-state features provide us crucial information on the degree of crystallinity of the dust.

Ionization of the envelope (Spectroscopy) The onset of the ionization of these envelopes can easily be traced by the detection of strong nebular emission lines, which are expected to appear only when the temperature of the central post-AGB star reaches a high enough temperature. They can be used as a diagnostic to determine the physical properties of the ionized gas and, in some cases, the chemical abundances of individual species. In the spectral range covered by CanariCam there are several important lines, such as 8.99 μm [Ar III], 10.5 μm [S IV], 12.8 μm [Ne II], and 18.7 μm [S III].

Finally, the combined information derived from the evolution observed in: i) the photospheric gas-phase spectral features, ii) the solid-state features coming from the dust, and iii) the overall spectral energy distribution can be used to model how the whole evolution from the AGB to the PN stage took place. This can be used to establish connections between the initial mass of the progenitor star and the final mass of stars in the PN stage and its effect on the chemical evolution of the Galaxy, a long-standing problem in stellar evolution.

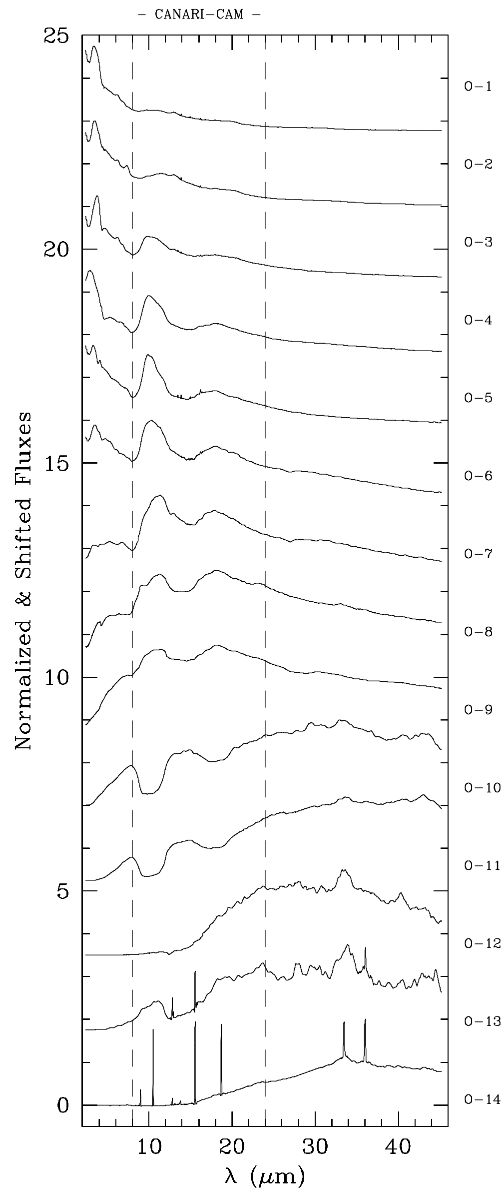

Fig. 1. One of the proposed evolutionary sequences: The evolution of high mass (4–8 $M_{\odot}$) O-rich AGB stars on their way to becoming PNe.