THE MILLIMETER AND SUBMILLIMETER SPECTRUM OF CRL 618

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Abstract

HIFI, the very high resolution heterodyne spectrometer will be able to carry out full spectral line surveys in the submillimeter domain (from ≃0.6 to ≃0.2 mm). Thus, many molecular, atomic and ionic lines will be observed in a fast way with high resolving powers. In this contribution we present for the first time a complete spectral survey of CRL 618 at λ= 3, 2 and 1 mm. CRL 618 is one of the few clear examples of a C–rich proto–planetary nebula. Data were taken using the Pico Veleta 30-m IRAM telescope between 1999 and 2000 and complemented with Caltech Submillimiter Observatory (CSO) observations. This kind of surveys, in addition to being an excellent overview of the molecular content of this circumstellar envelope represents a preparatory study of the spectral survey programs that could be carried out with FIRST/HIFI and also with PACS and SPIRE on C–rich evolved stars such as IRC+10216, CRL 2688, CRL 618 or NGC 7027.

Key words: line identification–surveys–stars: post-AGB–stars: carbon– stars: circumstellar matter–stars: individual: CRL 618–ISM: molecules– radio lines:stars

1. Introduction

CRL 618 is an excellent example of a C–rich proto planetary nebula (hearafter proto–PN). It has an ultracompact HII region created by a B0 central star (30000 K). The whole complex is surrounded by a thick and dusty molecular envelope. Extreme physical conditions due to UV radiation field and large shocks associated with high molecular winds (with velocities up to 200 Km/s, Cernicharo et al. 1989, Herpin et al. 2001) drive an interesting but complex chemistry. Far–IR observations have proved the presence of O–bearing molecules such as H_2O and OH (Herpin & Cernicharo 2000) together with H_2CO (Cernicharo et al. 1989). These species are not present in the envelope of IRC+10216 (Cernicharo, Guélin & Kahane 2000), the prototype of AGB C–rich circumstellar envelope. We have started a millimeter and submillimeter survey with the 30–m and CSO telescopes in order to identify all abundant polar molecular species. The CRL 618 spectral survey is characterized by a forest of molecular and recombination lines. Mainly, pure rotational lines from ground and highly vibrationally excited states with energies up to 2000 K of HC_3N, HC_5N, HC_7N and its ^{13}C subtituted species contribute to the detected features. Lines show P–Cygni profiles at 3 and 2 mm and emission profiles at 1 mm and shorter wavelengths. The large abundance of cyanopolyynes, acetylenic chains, methane, methylpolyynes and the detection of benzene in the infrared (see Cernicharo et al. 2001 a&b) indicate that during the transition from the AGB stage to the PN phase, C–rich proto–PN will become the best organic chemistry factories in the space. Probably at this early stage, large amounts of acetylene and methane still in the gas phase allow the growth of new series of small hydrocarbons through photochemical reactions. These species could be the small blocks from which the large C–rich molecules responsible for the emission in the Unidentified Infrared Bands (UIBs) could be created. Thus, if large policyclic aromatic hydrocarbons are the UIBs carriers, this suggest that PAH formation is linked to the chemical processing during the post–AGB phase and may actually proceed through different chemical pathways than previously thought. Our mm, submm and Infrared observations of CRL 618 lead to a scenario in which the chemical network is dominated by the photolysis of key molecules such as CH_4, C_2H_2 and by subsequent polymerization of longer units. Besides, other mechanisms involving shocks, grain desorption or grain–surface chemistry could be also important. Here we will only present some representative spectra at λ=3, 2, 1 mm. The whole spectral survey will be presented elsewhere. Its continuation with FIRST/HIFI at shorter wavelengths will provide a unique perspective of the chemistry in this crucial phase of the late–type stars evolution.

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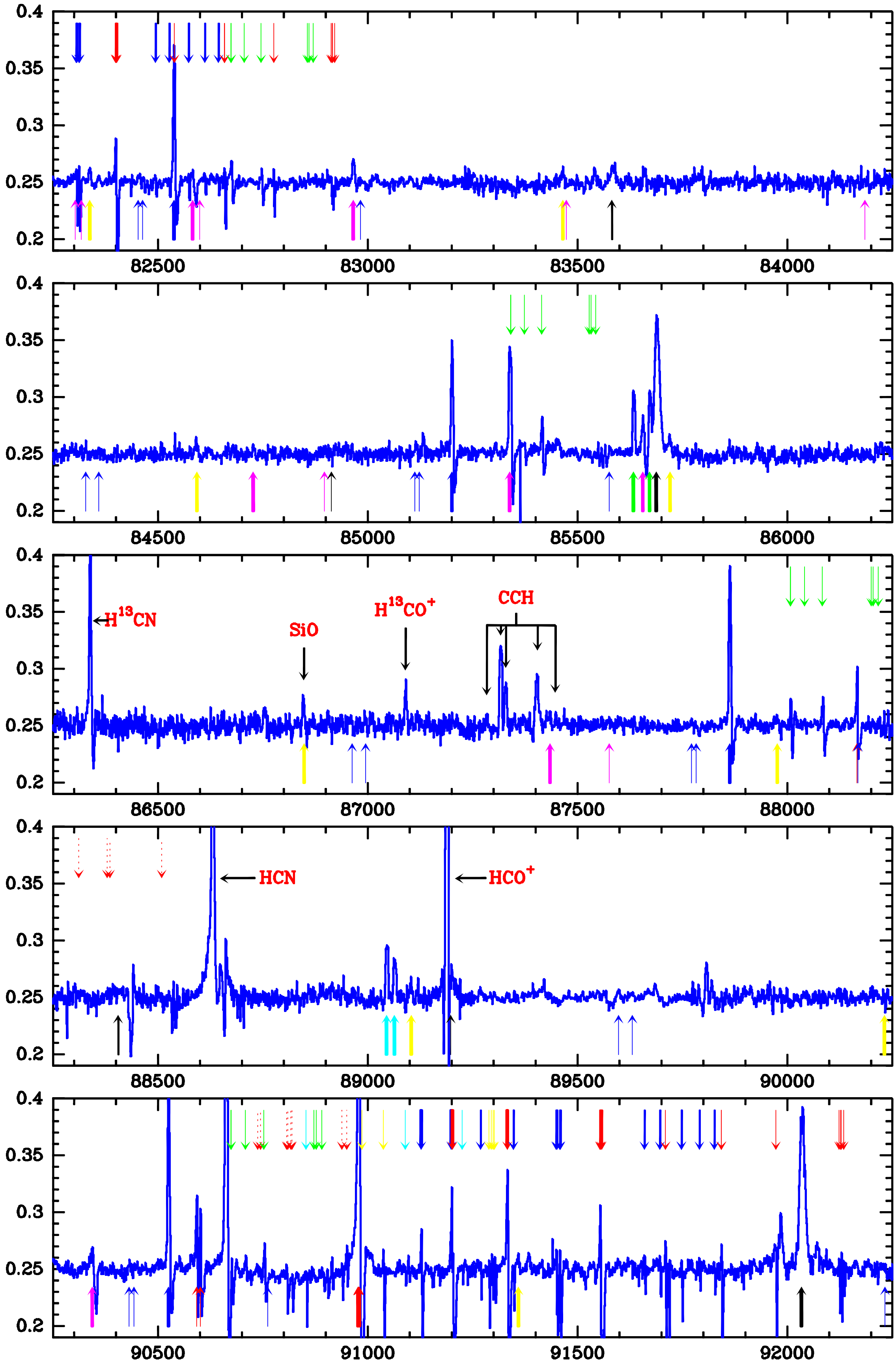

Figure 1. Part of the λ 3 mm spectral survey of CRL 618. Ordinate is T_A^*, the antenna temperature corrected for atmosphere absorption and spillover losses. The abcissa correspond to the Rest Frecuency (MHz). Main features are labelled with vertical arrows. See figure 4 for the colour codification.

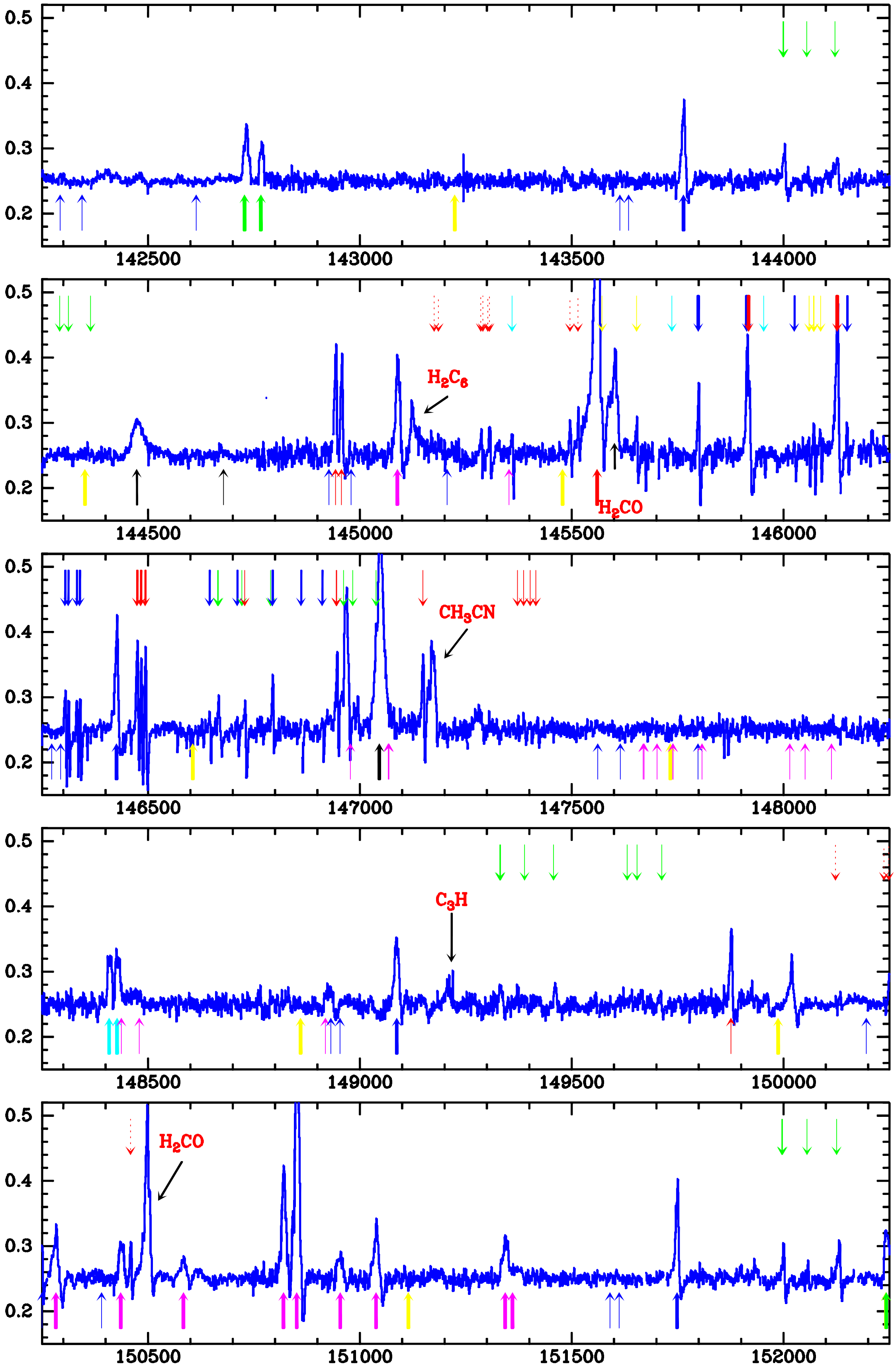

Figure 2. Part of the λ 2 mm spectral survey of CRL 618. Ordinate is T_A^*, the antenna temperature corrected for atmosphere absorption and spillover losses. The abcissa correspond to the Rest Frecuency (MHz). Main features are labelled with vertical arrows. See figure 4 for the colour codification.

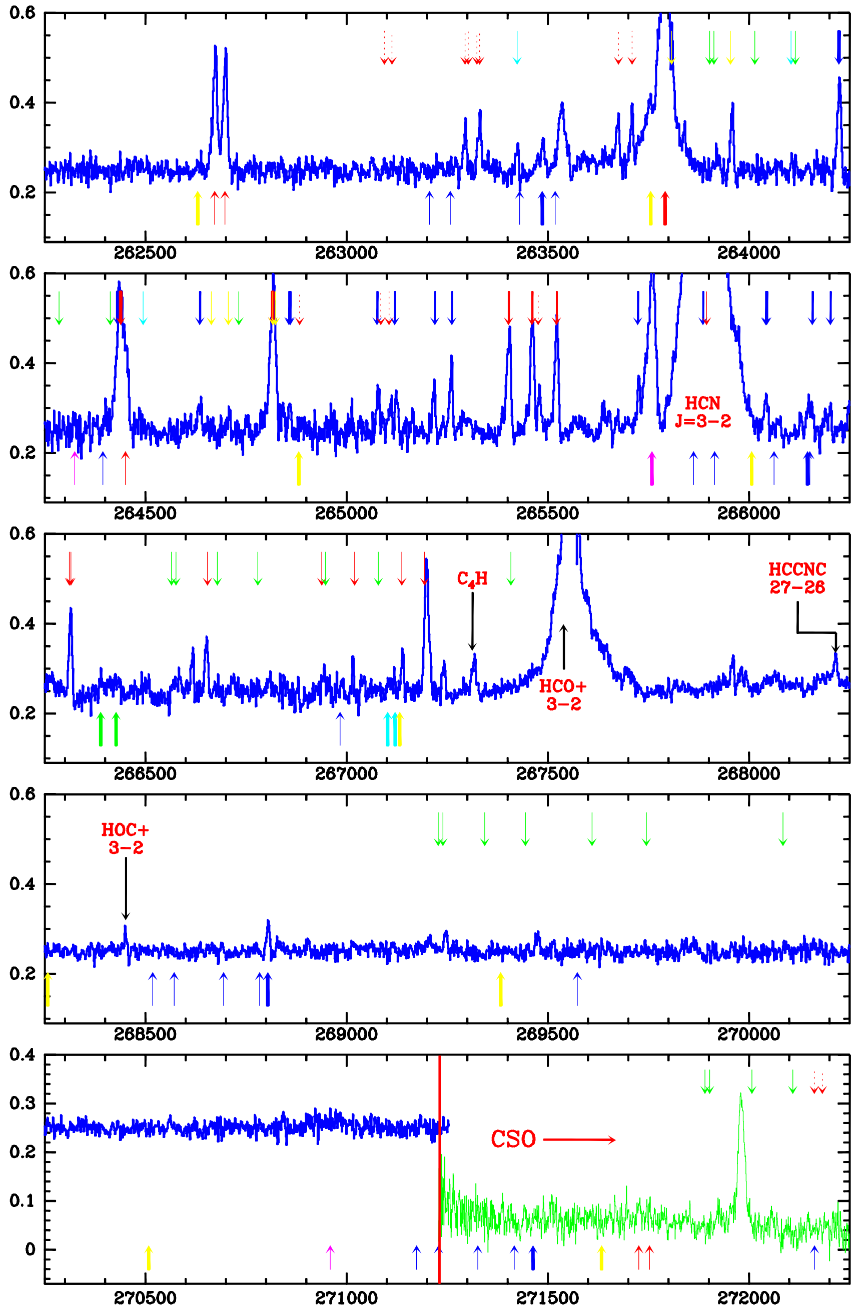

Figure 3. Part of the λ 1 mm spectral survey of CRL 618. Ordinate is T_A^*, the antenna temperature corrected for atmosphere absorption and spillover losses. The abcissa correspond to the Rest Frecuency (MHz). Observations above 271250 MHz come from the CSO telecope. Differences in continuum levels are due to the different beam sizes of both telescopes. Main features are labelled with vertical arrows. See figure 4 for the colour codification.

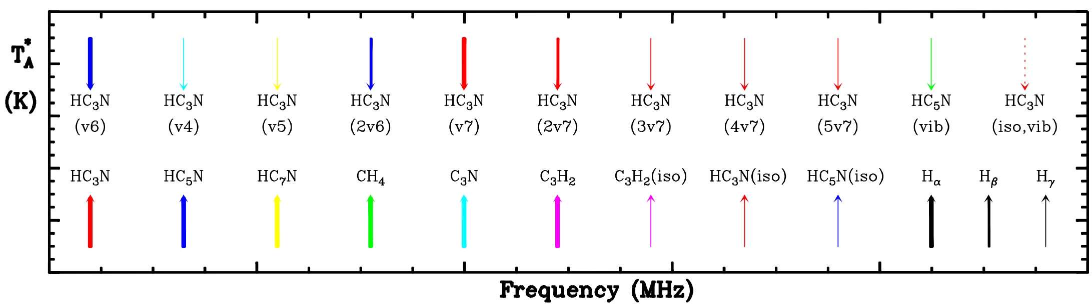

Figure 4. Colour codification for main detected molecular and recombination lines.