HCN around IRC +10 216: a HIFI view

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Abstract

Determining the chemical and physical properties of the circumstellar envelopes (**CSEs**) of asymptotic giant branch (**AGB**) stars is important for our understanding of late stellar evolution and of the mass return to the ISM. In order to probe the CSE of the carbon-rich AGB star **IRC+10216** we carried out a high resolution **spectral survey in the range 480-1910 GHz using HIFI**. A significant fraction of all detected lines originate from **HCN**: we measure thermal emission for the **J=6-5,...,21-20** rotational transitions within more than 10 different vibrationally excited states, covering energy levels up to above 15000 K. After H_2 and **CO**, HCN is the most abundant molecule in the winds of carbon-rich evolved stars.

1 CSE model

We have set up the most detailed physical model of the stellar wind of IRC+10 216 to date based on **radiative-transfer modelling of the spectral energy distribution (SED) and of the emission of CO rotational transitions**. This model constrains the dust properties, density and velocity structures, and the temperature profile in the CSE.

De Beck et al. 2012

Future models

3b Cooling the CSE

The many transitions of HCN, in combination with the relatively easily excited ν_2 bending mode at ~14µm - where the SED of IRC +10 216 peaks - can give rise to a **more efficient cooling than CO transitions**. HCN hence plays an important role in the energy balance of the CSE of a **carbon-rich** AGB star, similar to the role played by H_2O in the CSEs of oxygen-rich AGB stars (Maercker et al. 2008). This needs to be implemented in future models for all C-rich AGB stars.

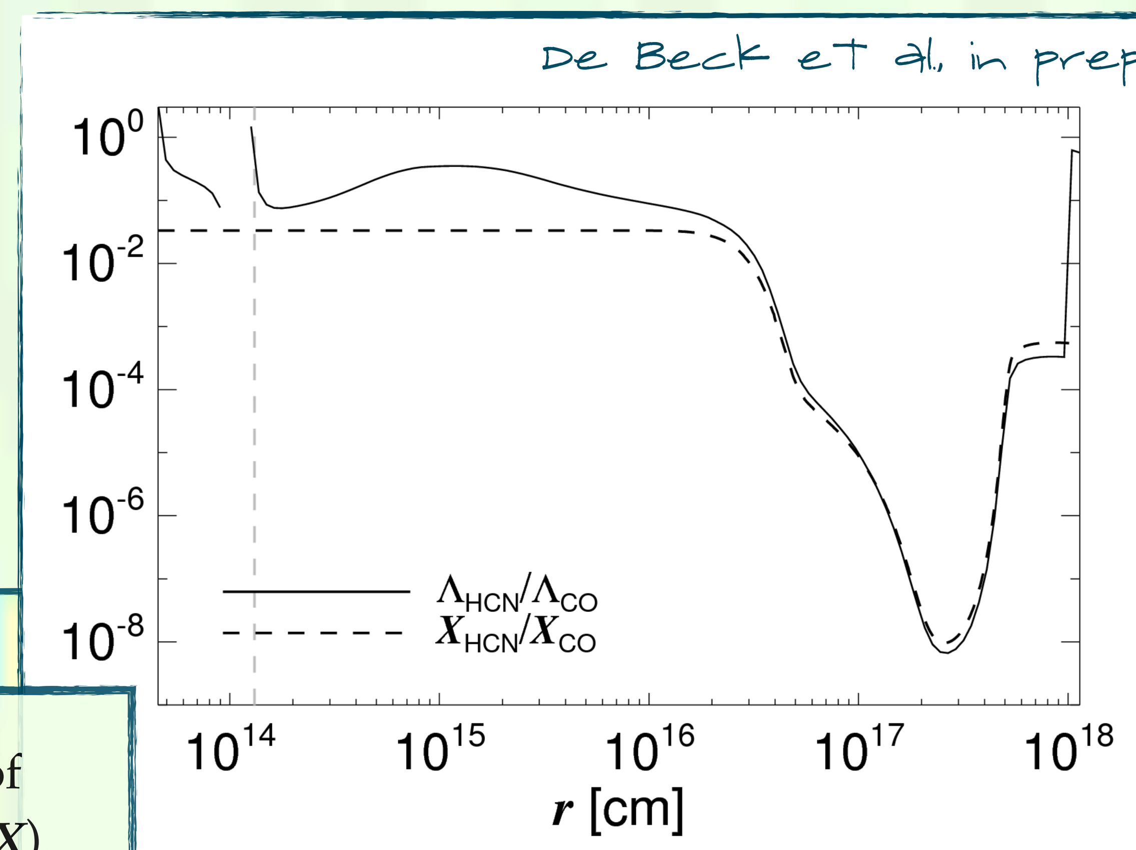

Fig. 3 HCN and CO: ratios of cooling rates (**Λ**) and abundances (*X*).

2 HCN data

We identified **~120 HCN transitions** in the HIFI survey of IRC +10 216.

[Notation of vibrational states: (ν_1, ν_2, ν_3).]

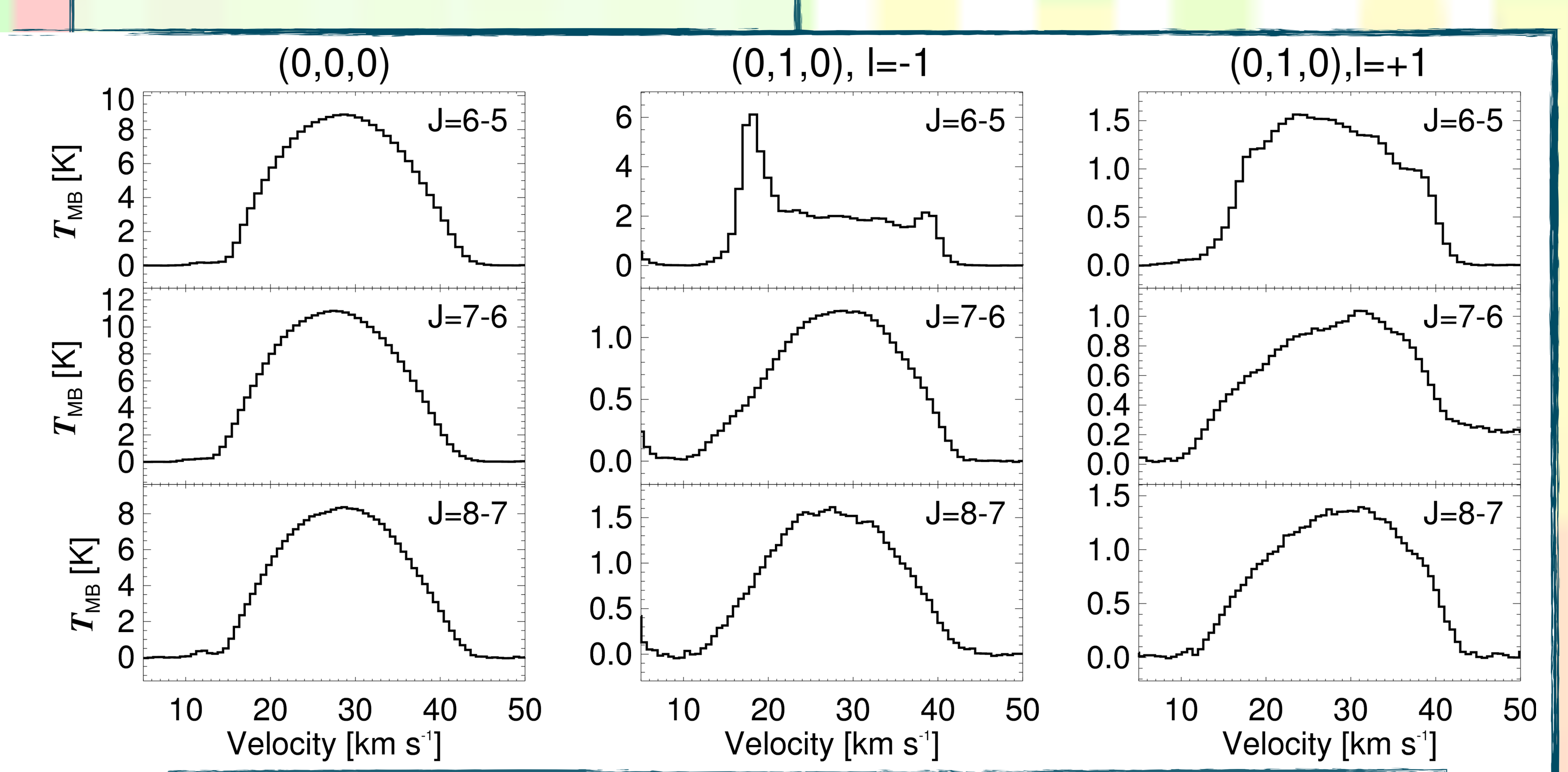

Fig. 1 Selection of HCN lines from the HIFI survey.

3a HCN model

We use the CSE model as the basis for detailed NLTE radiative-transfer modelling of the HCN emission. The modelled emission probes the CSE **from the stellar atmosphere out to ~300 stellar radii** (≈900AU), where HCN is photo-dissociated.

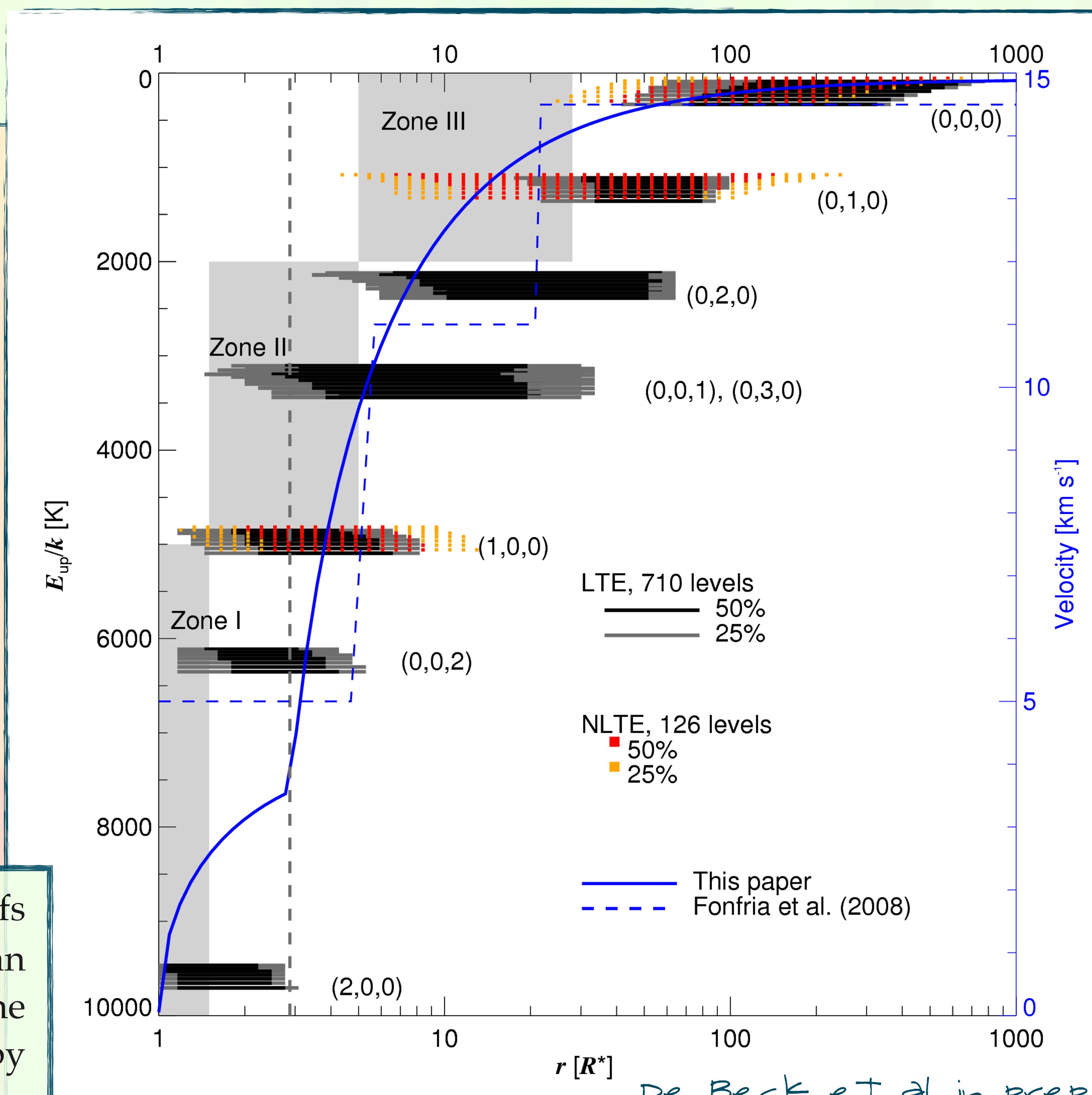

Fig. 2 The regions traced by HCN emission (corresponding to 25% and 50% cutoffs in intensity) for an LTE model with 710 molecular energy levels (grey/black) and for an NLTE model with 126 levels (red/orange). We show the energy levels involved in the transitions, and the gas velocity (blue) in the CSE. Zones I, II, and III were defined by Fonfría et al. (2008) and Cernicharo et al. (2011).

Related literature

HIFI scan of IRC + 10 216

Cernicharo et al., 2010, A&A, 521, L8 — SiC_2
De Beck et al., 2012, A&A, 539, A108 — CO, C_2H (CSE model)

HCN around IRC +10 216

Cernicharo et al., 1996, A&A, 315, L201 — ISO
Cernicharo et al., 2011, A&A, 529, L3 — IRAM 30m (J=1-0, 3-2)
Fonfría et al., 2008, ApJ, 673, 445 — TEXES (mid-IR)

Heating/cooling in the CSEs of AGB stars

Decin et al., 2006, A&A, 456, 549 — GASTRoNOoM RT
Maercker et al., 2008, A&A, 479, 779 — H_2O (O-rich AGB CSEs)

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