PROBING THE ABUNDANCE OF SiO AND HCN THROUGHOUT THE STELLAR WIND OF R DOR

M. Van de Sande, L. Decin, R. Lombaert, T. J. Millar, T. Khouri, C. Walsh, X. Li

ABSTRACT

R Dor is an oxygen-rich AGB star characterised by a low mass-loss rate. Using retrieval methods, we found abundance profiles for SiO and HCN, two chemically important molecules. By comparing these results to those of forward chemistry modelling we will be able to constrain the dominant chemical pathways within the stellar wind. They will also enable us to improve the forward chemistry models, through incorporating dust-gas reactions. The same methodologies will be applied to the abundance profiles retrieved for the O-rich AGB star IK Tau (Decin et al. 2010), which is characterised by a high mass-loss rate.

METHODS

One-dimensional, spherically symmetric codes

Retrieval

In-house non-LTE radiative transfer code GASTRoNOoM (Decin et al. 2006, 2010)
Models the thermodynamics and kinematics of the wind and abundance profiles of molecules

Forward chemistry

Based on UMIST database (McElroy et al. 2013)
Gas-phase reactions only
Yields abundance profiles and chemical pathways

RESULTS

• Range in abundance profiles
  • Indistinguishable fit to molecular data
  • Criteria: integrated line flux (line strength)
    log-likelihood function (line shape)
  • Range well constrained
  • Allows for comparison to forward chemistry model
  • No evidence of condensation of SiO onto dust grains

FUTURE WORK

• Compare with forward chemistry models
  • Gas-phase reactions only
  • Include dust-gas reactions
• Compare forward chemistry models to results of IK Tau
  • High mass-loss rate and low mass-loss rate
  • Difference in dominant pathways, dust nucleation...

• Oxygen-rich AGB star
• Low mass-loss rate: 9 x 10⁻⁸ Mₜsun/yr
• Van de Sande et al. (in prep.):
  Envelope model – dust and gas
  Abundance profiles of SiO and HCN
• Data: SEST, APEX, Herschel HIFI, PACS, and SPIRE
• Future work: ALMA data

Distance 1 Rₜ
Temperature ~2000 K
~2000 Rₜ
~3 x 10³ K
~100 Rₜ
~100 K

C/O < 1
Stellar photosphere

Dynamical atmosphere
Molecules form dust
Molecules absorbed onto dust

Silicates

HCN

SiO

Oxides

CO

Non-equilibrium chemistry

Pulsations
Shocks

Acceleration
Wind formation

Circumstellar envelope

Wind driven
Reaches terminal velocity

Interstellar radiation field

C

O

H

H₂

OH

OH⁺

H₂O

CS

H₂S

C₆H₆

C₅H₆

SiO

HCN

SiS

SO

SO₂

→

Physical structure (derived from CO)
Radiative transfer
Ray tracing of emission lines

Abundance profile

RETRIEVAL

FORWARD CHEMISTRY

Parent species + Physical structure
Chemical network
Abundance profile + Chemical pathways

SiO

HCN