Chemistry and IR Emission from PAHs in Protoplanetary Disks

Ruud Visser

Promotor: Ewine van Dishoeck
Co-workers: Jean-Charles Augereau (postdoc), Vincent Geers (PhD)
Leiden Observatory
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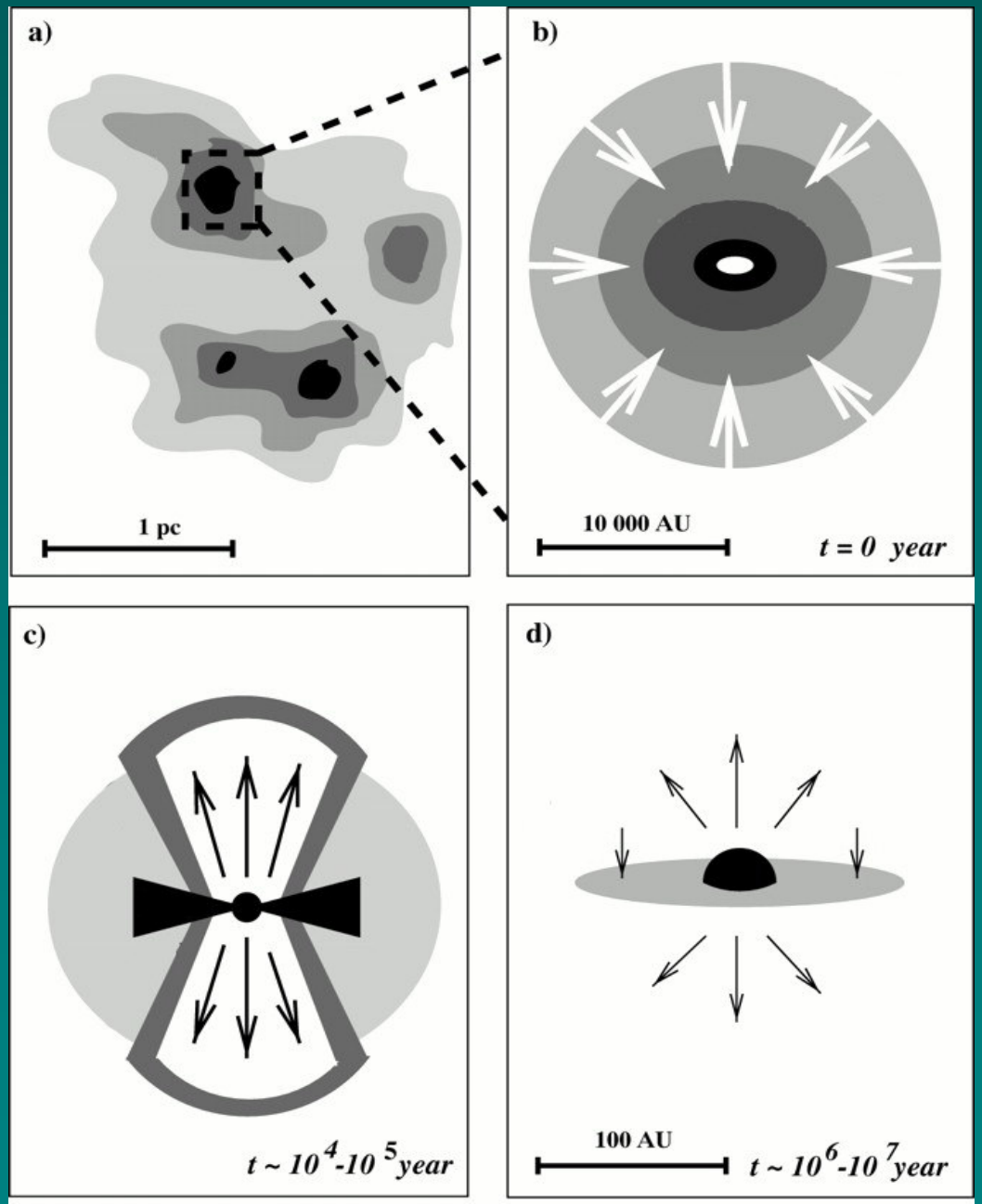
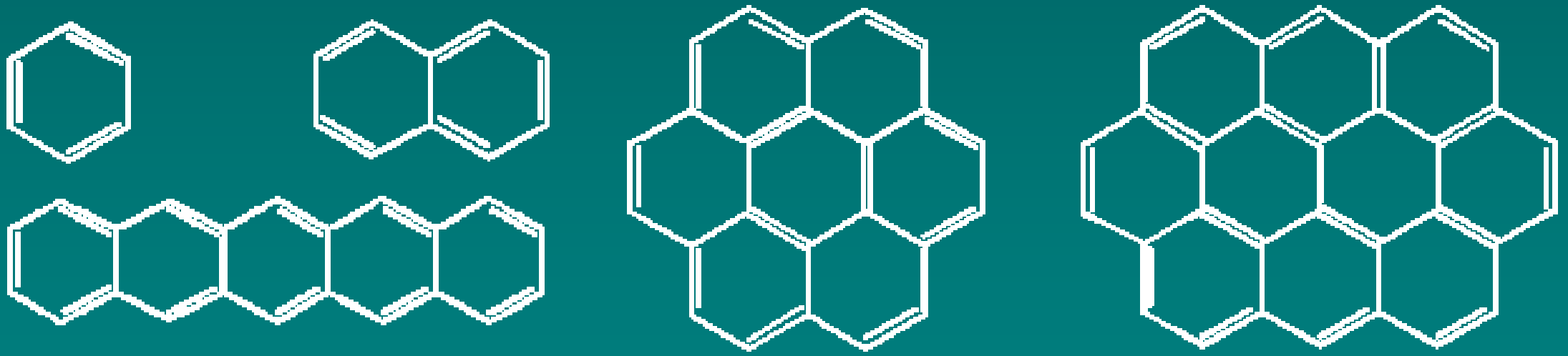
Star and planet formation



van Dishoeck & Blake 1998
image by M.R. Hogerheijde

Introduction to PAHs

- PAH: Polycyclic Aromatic Hydrocarbon
  ≈ skeleton of carbon rings,
  hydrogen atoms around the edge



- Emit in mid-IR (3.3, 6.2, 7.7, 8.6, 11.3 μm)
- Observed throughout the universe

blue:
3.6 μm

green:
4.5 μm

orange:
5.8 μm

red:
8.0 μm
(PAH)

SG, face on
2 Mpc away
in Sculptor

Spiral Galaxy NGC 300 **Spitzer Space Telescope • IRAC**

NASA / JPL-Caltech / G. Helou (Caltech) ssc2004-07b

Back to protoplanetary disks…

Questions to be answered

- What do PAHs tell us about the disk (e.g. temperature, geometry)?
- How does their chemical, physical behaviour affect the disk?

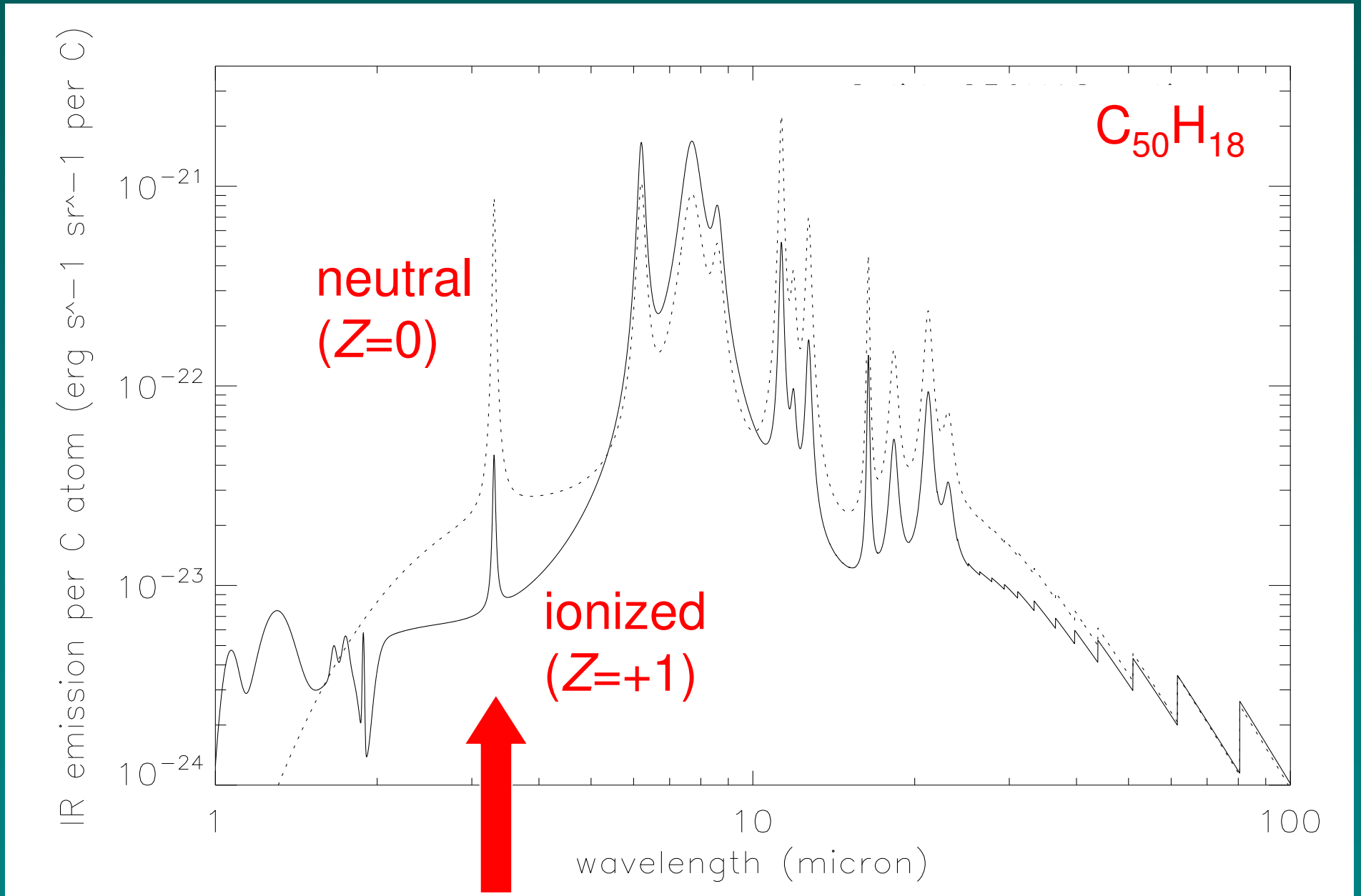
- What PAHs are present in disks?
- Where in the disk can they be found?

Chemistry and IR emission

Le Page et al. 2001, 2003
Draine & Li 2001

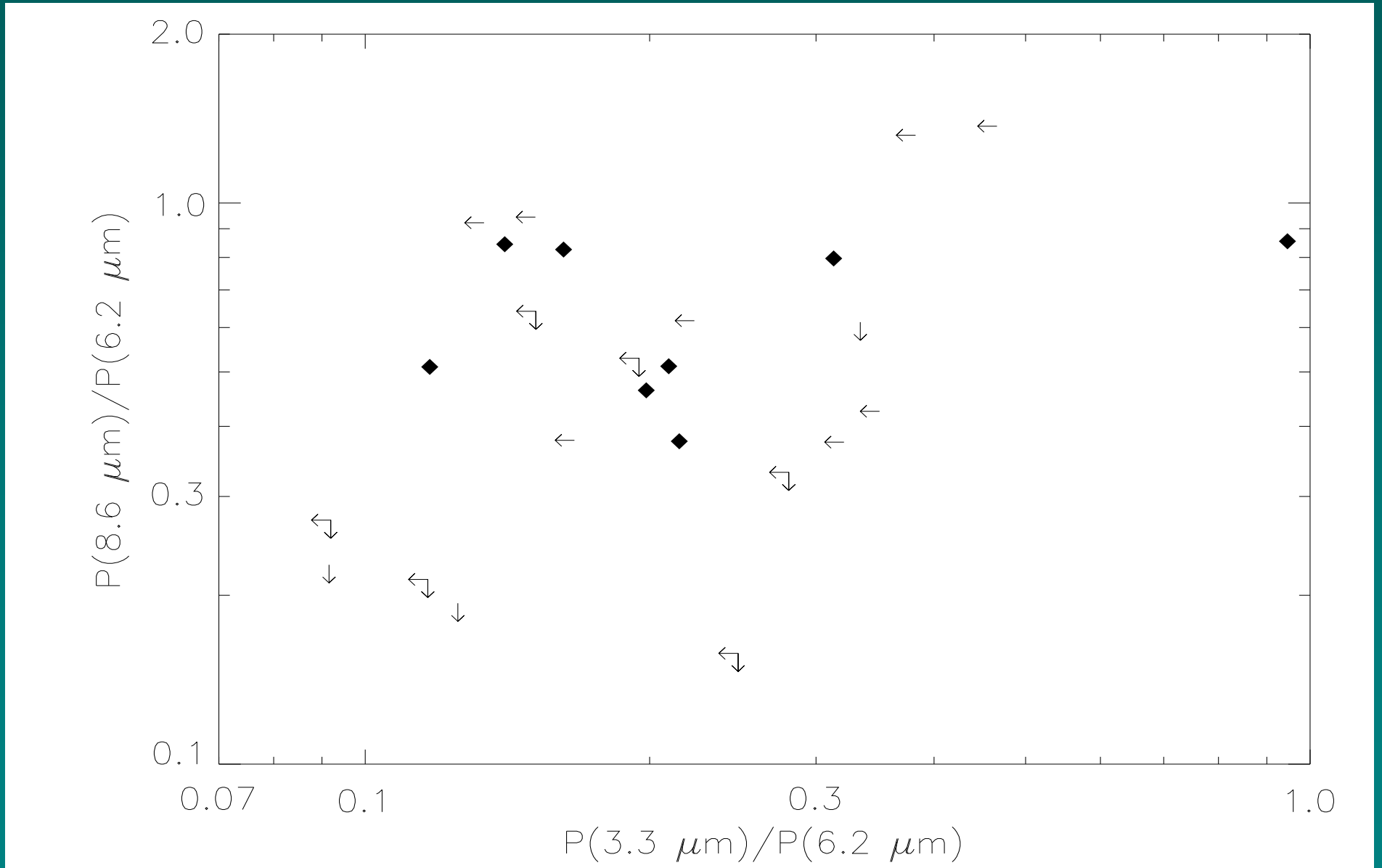
- Reactions:
  - $PAH + UV \rightarrow PAH^{+} + electron$
  - $PAH + electron \rightarrow PAH^{-} + IR$
  - $PAH + UV \rightarrow PAH_{-1} + H$
  - $PAH + H \rightarrow PAH_{+1} + IR$
- Distribution of charge/hydro states
- Each charge/hydro state: calculate IR spectrum

Example spectra



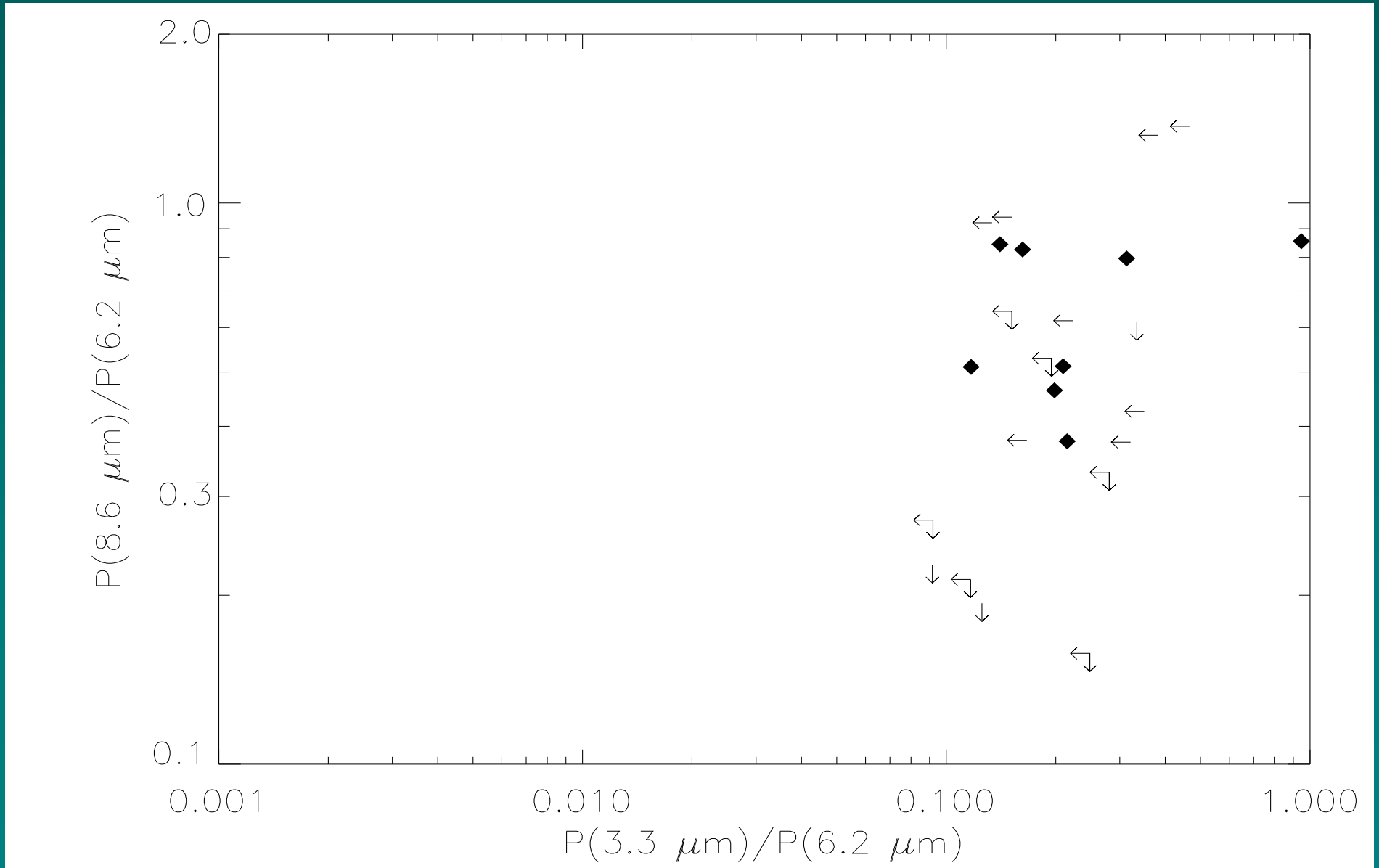
ISO observations

Acke & van den Ancker 2004

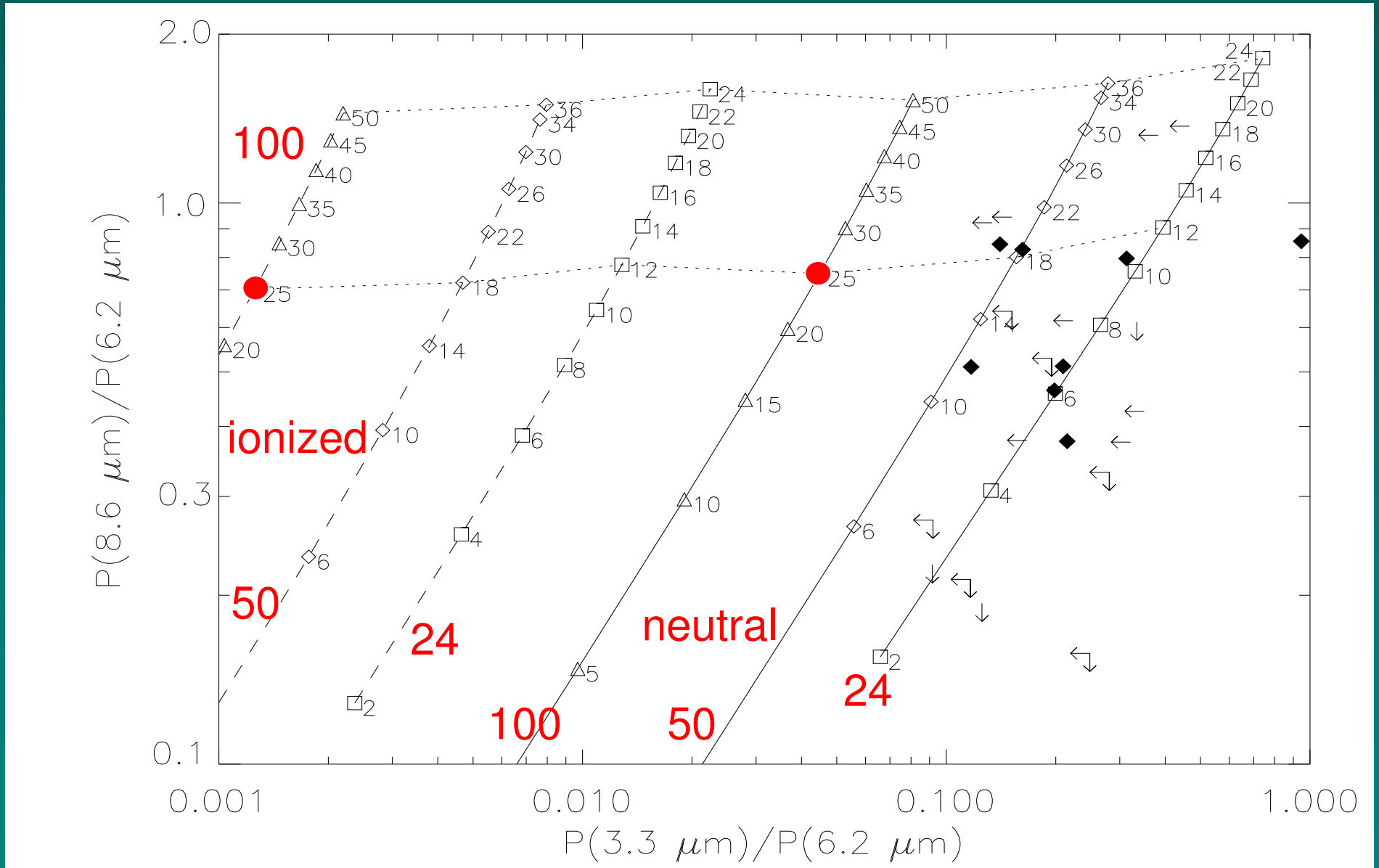


ISO observations

Acke & van den Ancker 2004



ISO observations & model data



Model vs. observations

- Observed PAHs apparently are:
  - smaller than 100 carbon atoms – possible
  - neutral – possible
  - somewhat dehydrogenated – unlikely

- Neutral and dehydrogenated: contradiction

Conclusions and outlook

- Chemistry model predicts charge and hydrogenation state for a PAH of given size in a given environment
- IR emission model predicts spectrum for a given PAH in a given charge/hydro state, in a given environment
- Future work: improve results, incorporate both models into disk model