

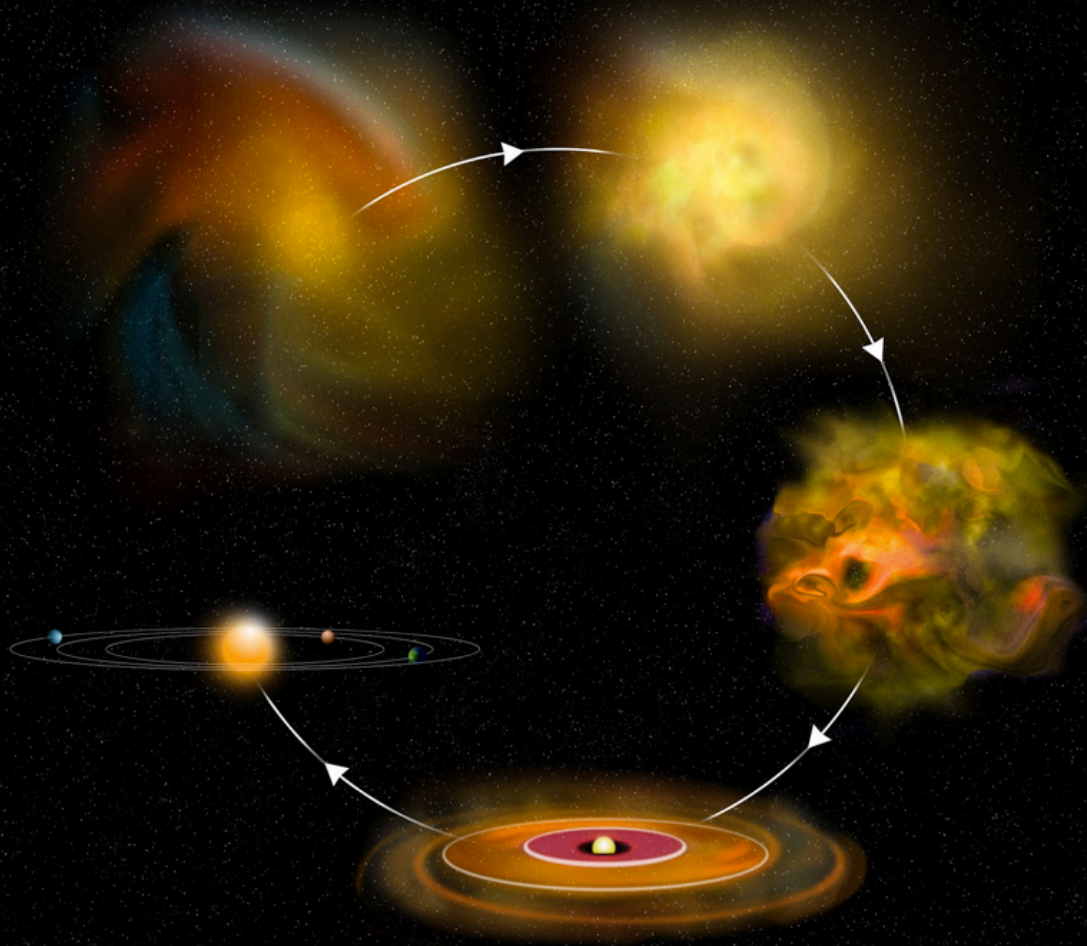
C/O or not C/O? Chemical fingerprinting of the birthplaces of exoplanets and brown dwarf companions

Taisiya Kopytova, Max Planck Institute for Astronomy



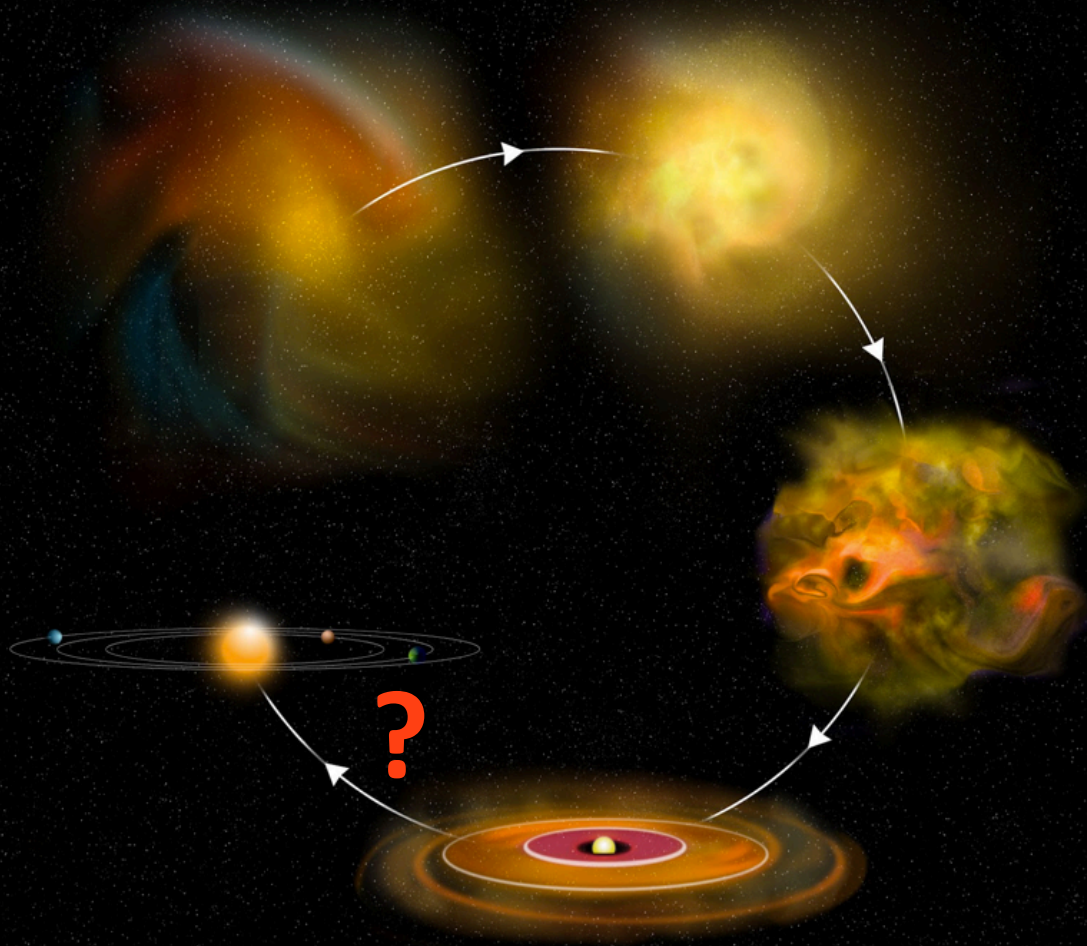
C. Hansen
M. Bonnefoy
D. Homeier
D. Hogg
N. Deacon
J. Schlieder
W. Brandner
E. Buenzli
C. Mordasini
C. Deen
F. Allard
Th. Henning

Planet formation in disks



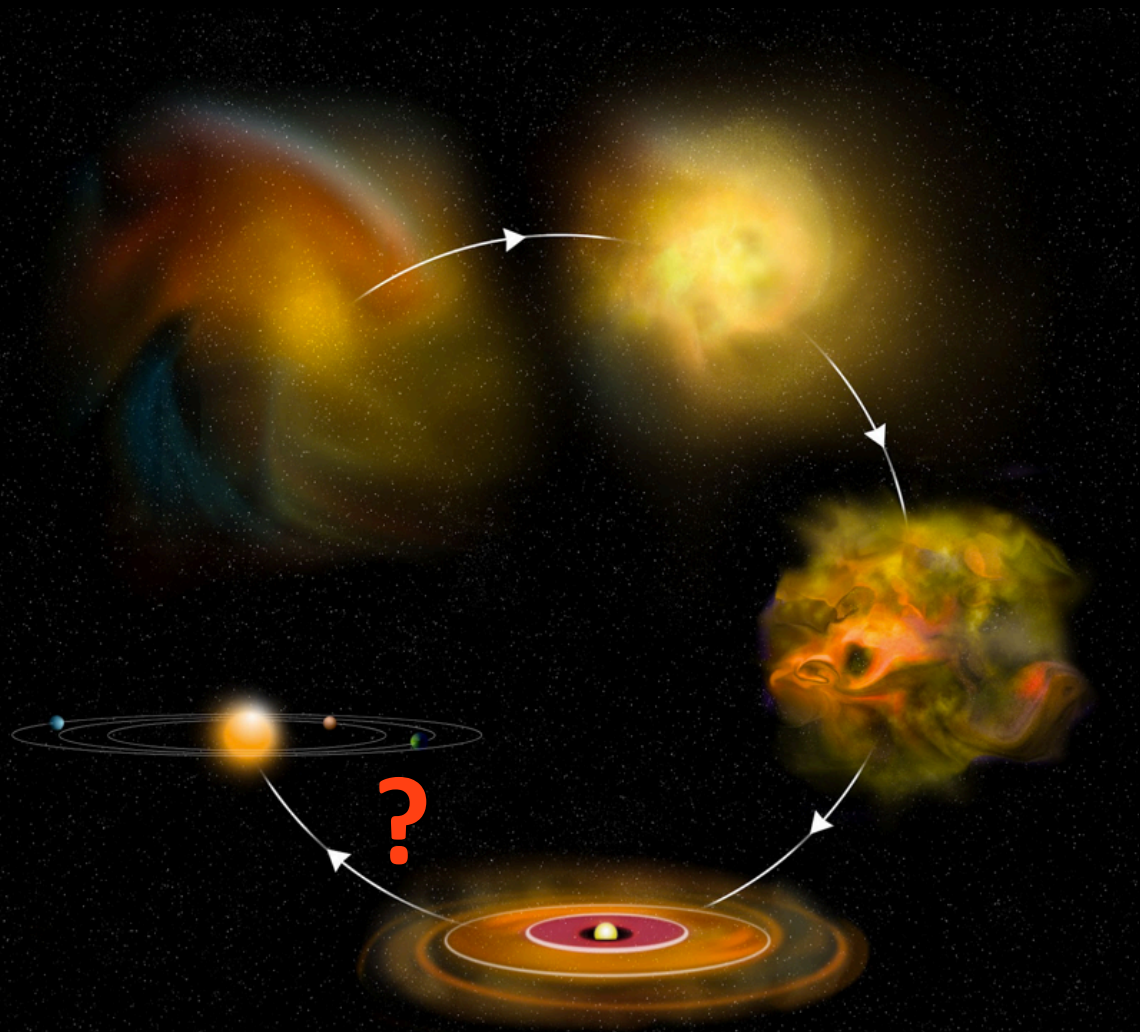
Bill Saxton, NRAO/AUI/NSF

Planet formation in disks



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Planet formation in disks

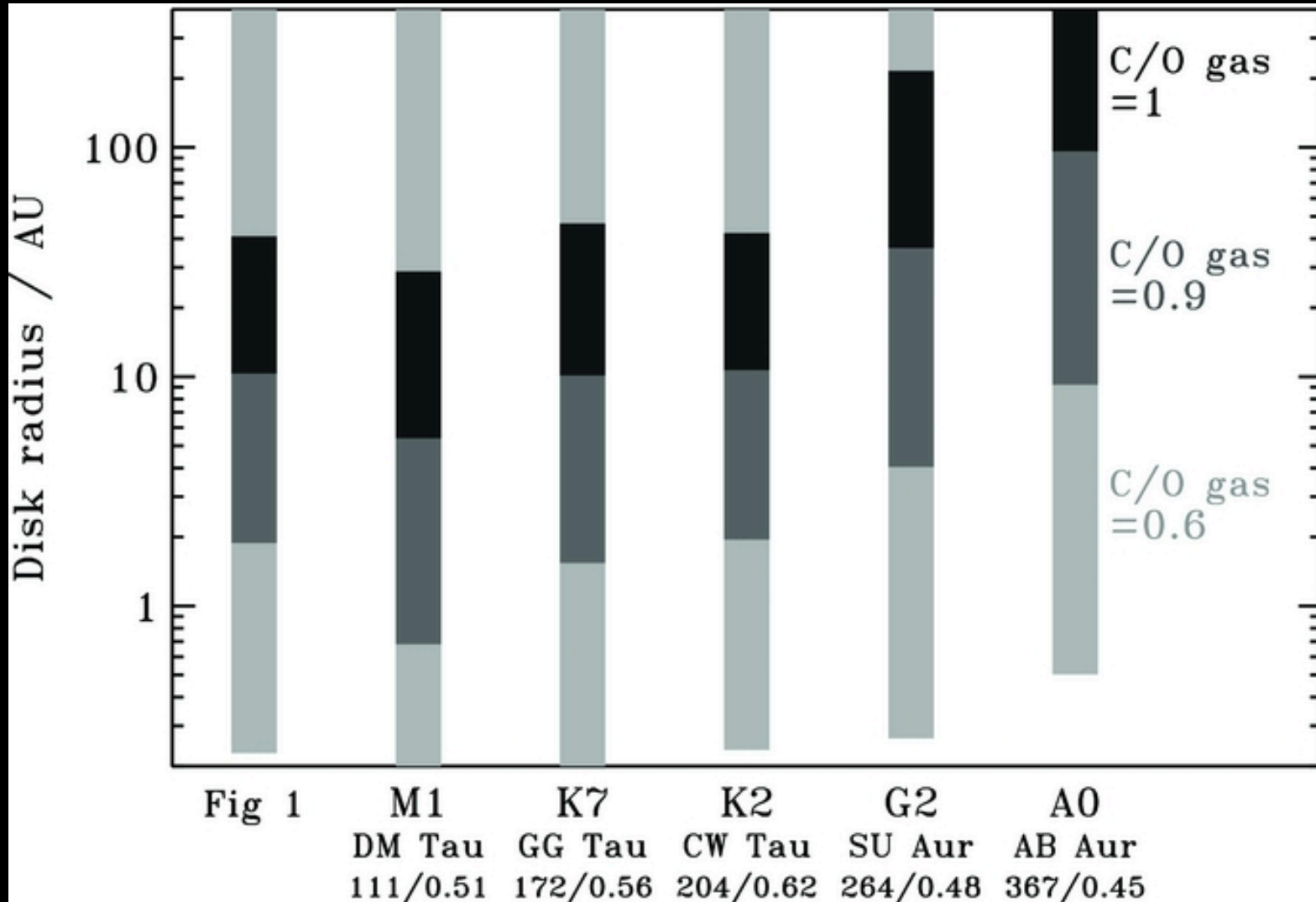


Core accretion

Gravitational instability

Bill Saxton, NRAO/AUI/NSF

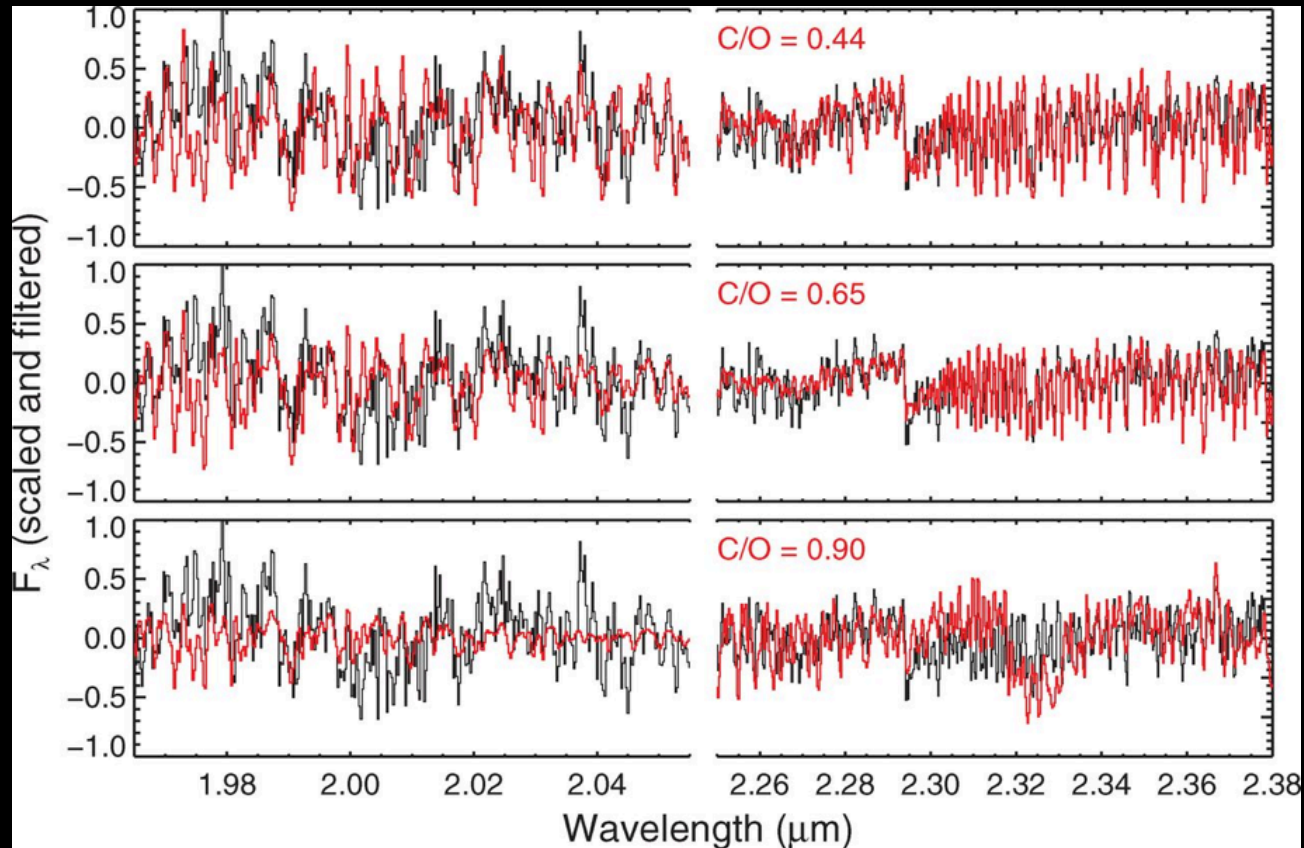
C/O ratio



Öberg et al. 2011

HR 8799c

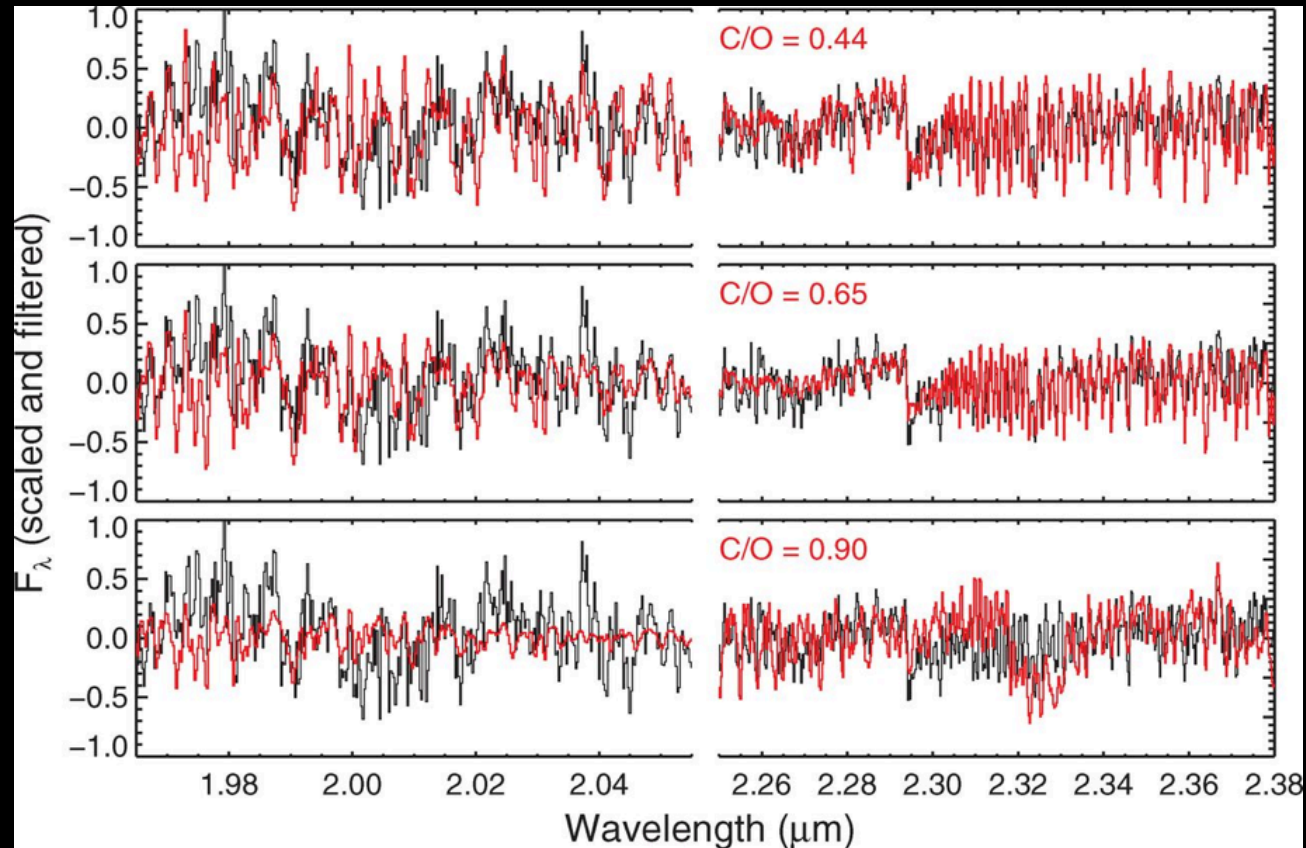
- Planets at 15-70 AU between H₂O and CO snowlines
- Measured C/O=0.65
- Excluded: gas-only CA (C/O<0.6)



Konopacky et al. 2013

HR 8799c

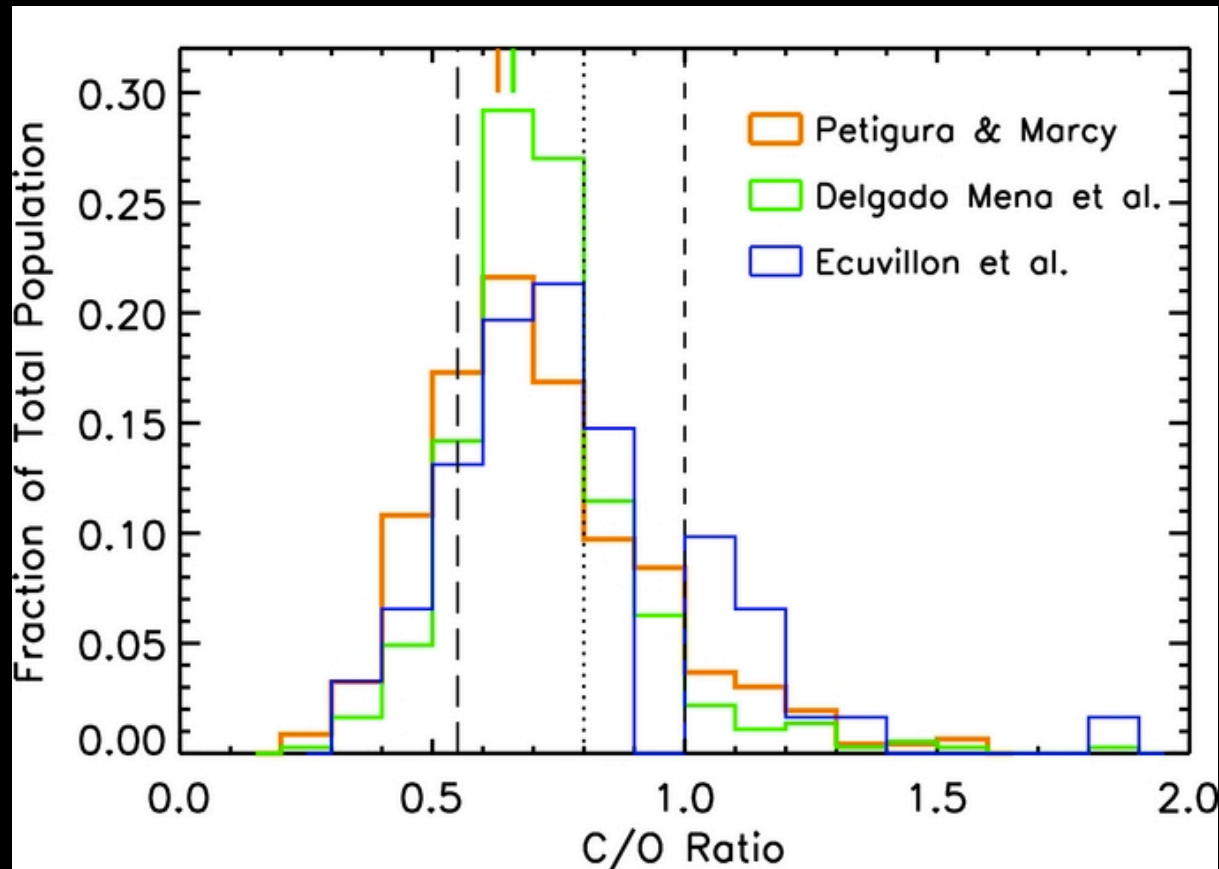
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Konopacky et al. 2013

Solar abundances for HR 8799?

Why forgetting host stars?



C/O in nearby solar-like stars, Fortney (2012)

Motivation

- Analyze host stars and companions in complex
- Feasibility: can we confidently measure C/O in principle?

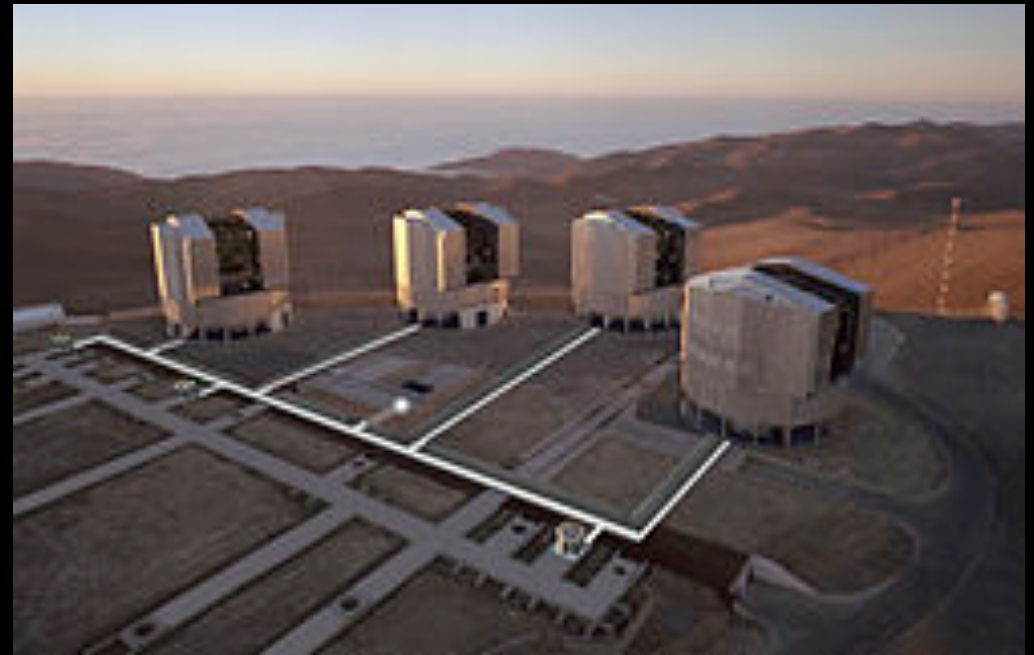
1. Host star survey

- FEROS at the 2.2m telescope in La Silla
- $R = 48\,000$
- Spectral coverage: 330-920 nm
- 20 host stars with directly imaged exoplanets



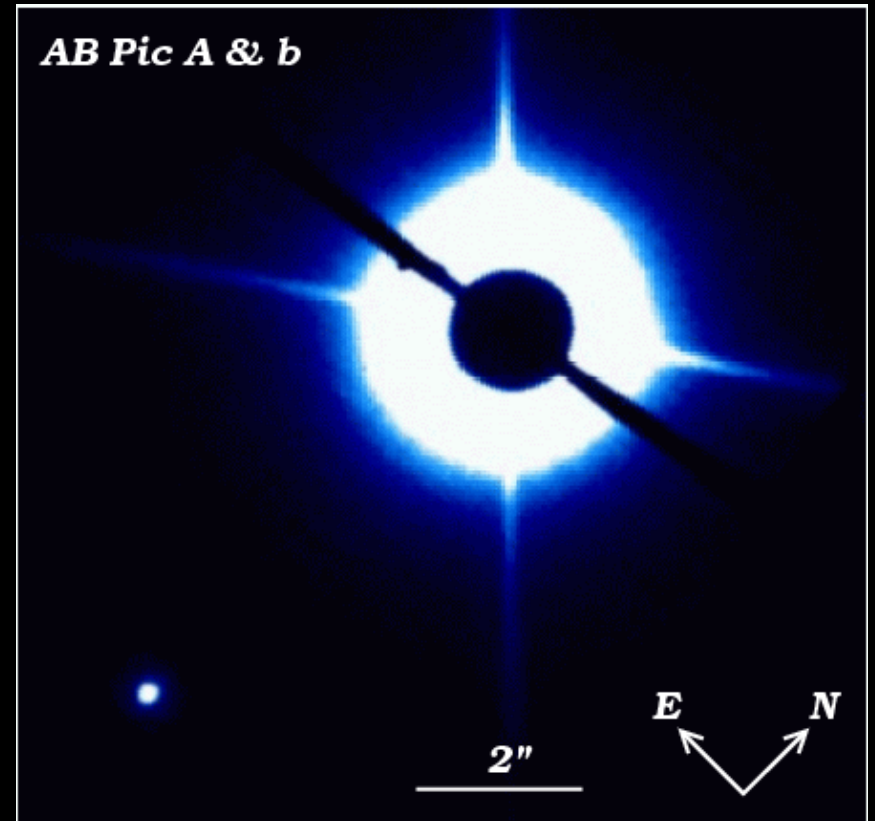
2. Companion survey

- SINONI/VLT at Paranal
- JHK spectroscopy
- $R = 1500, 2000$ or 4000
- 10 planet/BD companions



AB Pic A+B

- Host: K2V, $T_{\text{eff}}=4800\text{-}5000\text{K}$
- Companion:
 $T_{\text{eff}}=1600\text{-}1900\text{K}$
 $15M_{\text{Jup}}$ at 275 AU



Chauvin et al. (2005)

Metallicity determination

T_{eff} from color-T relations

Line synthesis

Fe
abundance

C/O ratios

Oxygen

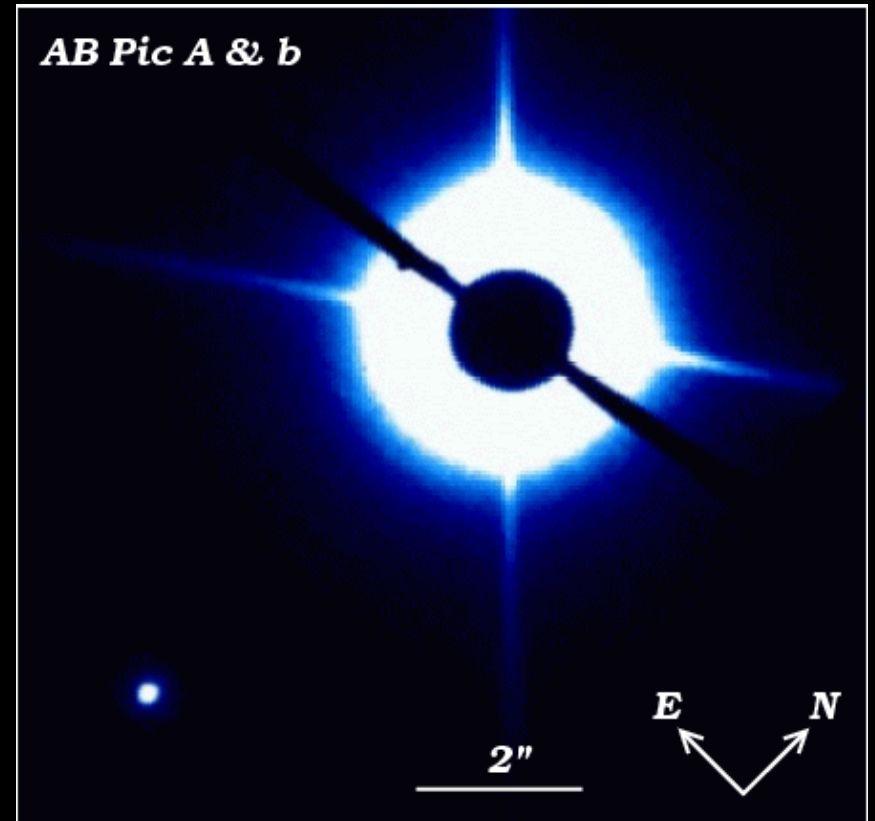
- Forbidden [O] at 6300 angstrom
- O triplet at 7772, 7774, 7775 angstrom

Carbon

- Various C lines at: 5052, 5380, 6587, 7087, 7111, 7113, 7837 angstrom

AB Pic A

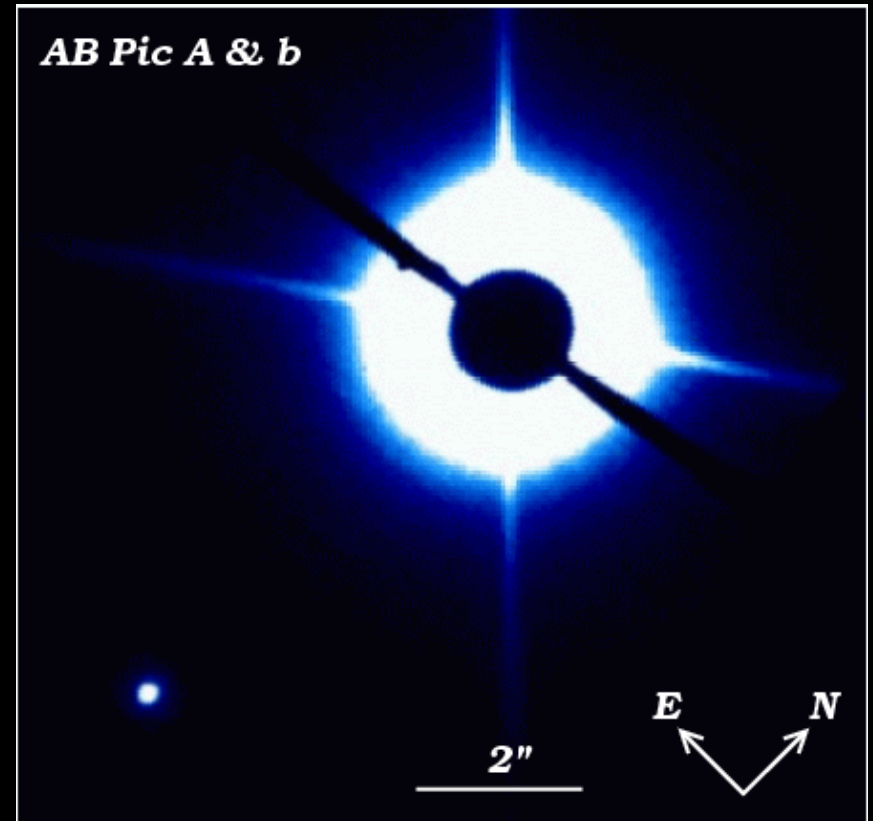
- $T_{\text{eff}}=5200\pm 100\text{K}$
- $[\text{Fe}/\text{H}]=-0.11\pm 0.15$
- $[\text{C}/\text{O}]=-0.03\pm 0.10$



Chauvin et al. (2005)

AB Pic B: chi-square minimization

- BTSettl (courtesy of D. Homeier)
- [Fe/H]: 0.0 and +0.3
- [C/O]: 0.0 and +0.2



Chauvin et al. (2005)

AB Pic B: chi-square minimization

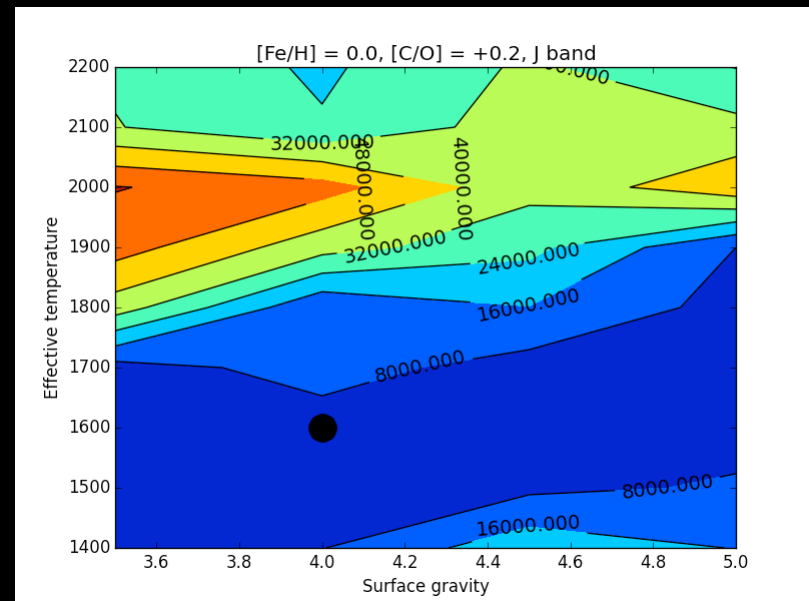
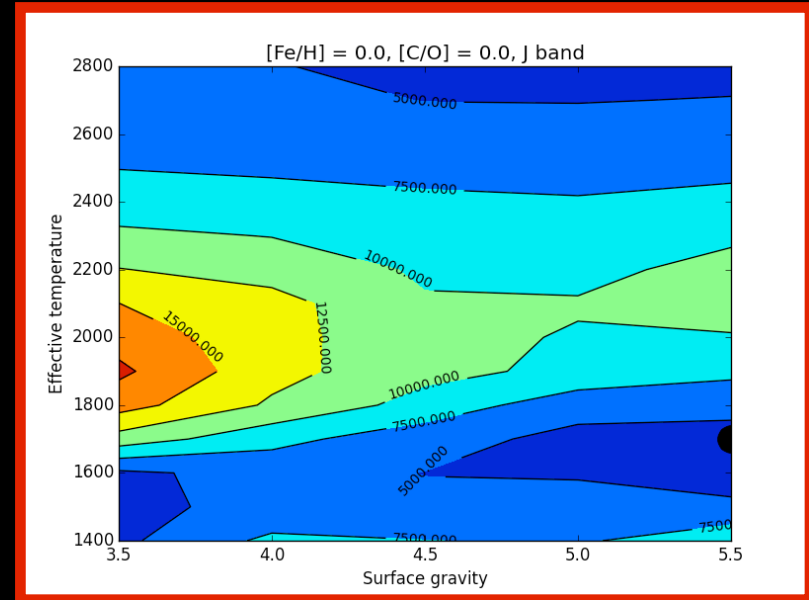
Best fits

All bands combined and H, K separately:

Teff = 1500K, logg = 3.5, [C/O] = +0.2

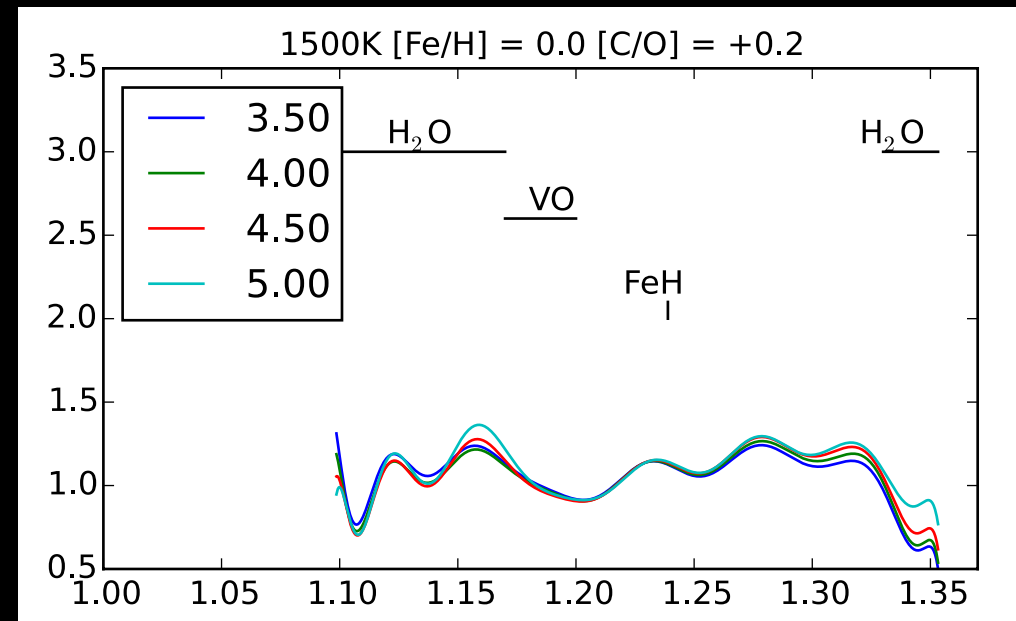
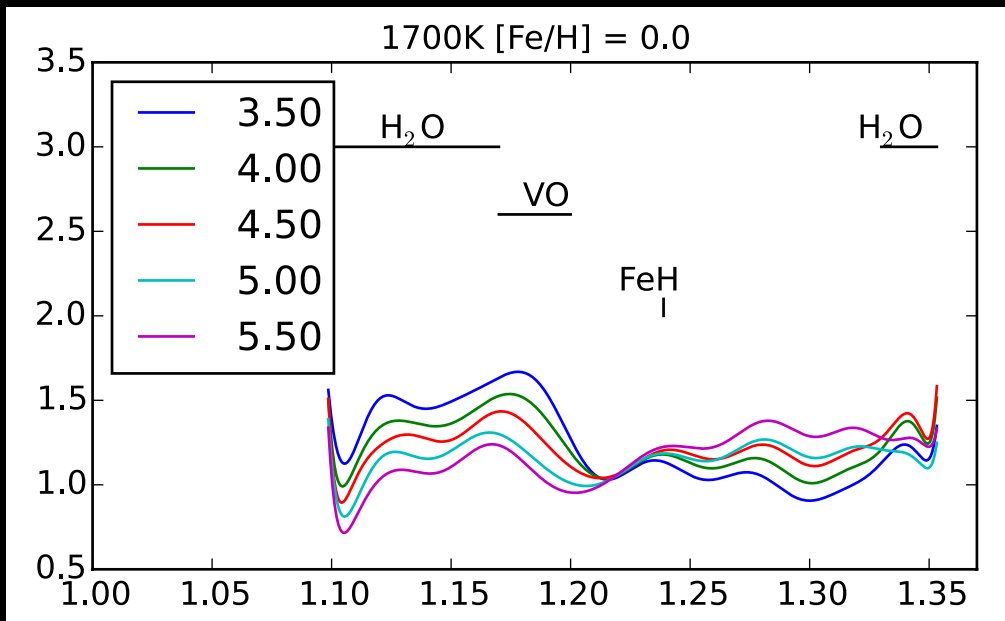
J band:

Teff = 1700K, logg = 5.5, [C/O] = 0.0

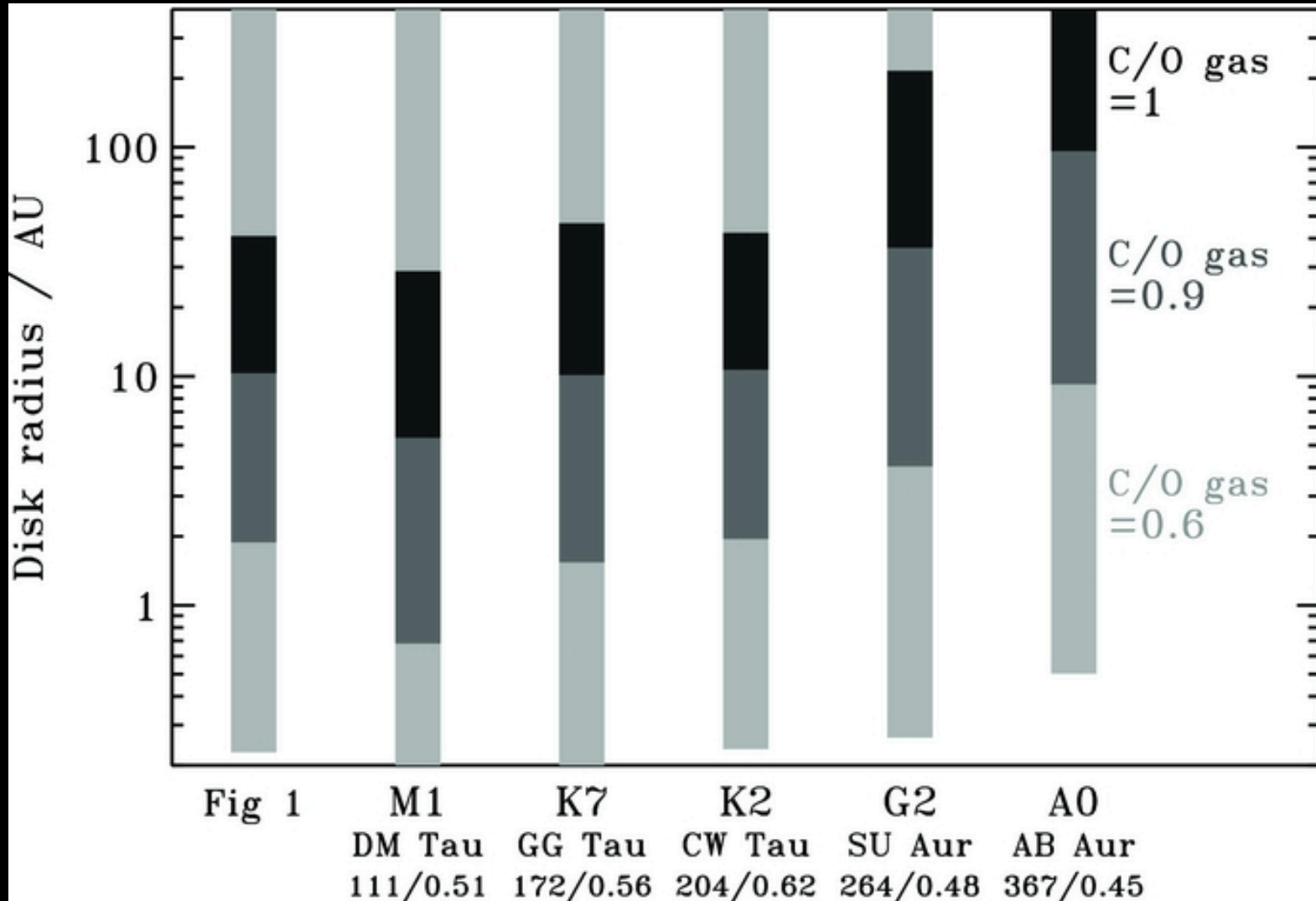


Problem diagnosis

“Fitting function”: $f_{\text{obs}}(\text{wavelength}) = g(\text{wavelength}) * f_{\text{model}}(\text{wavelength})$

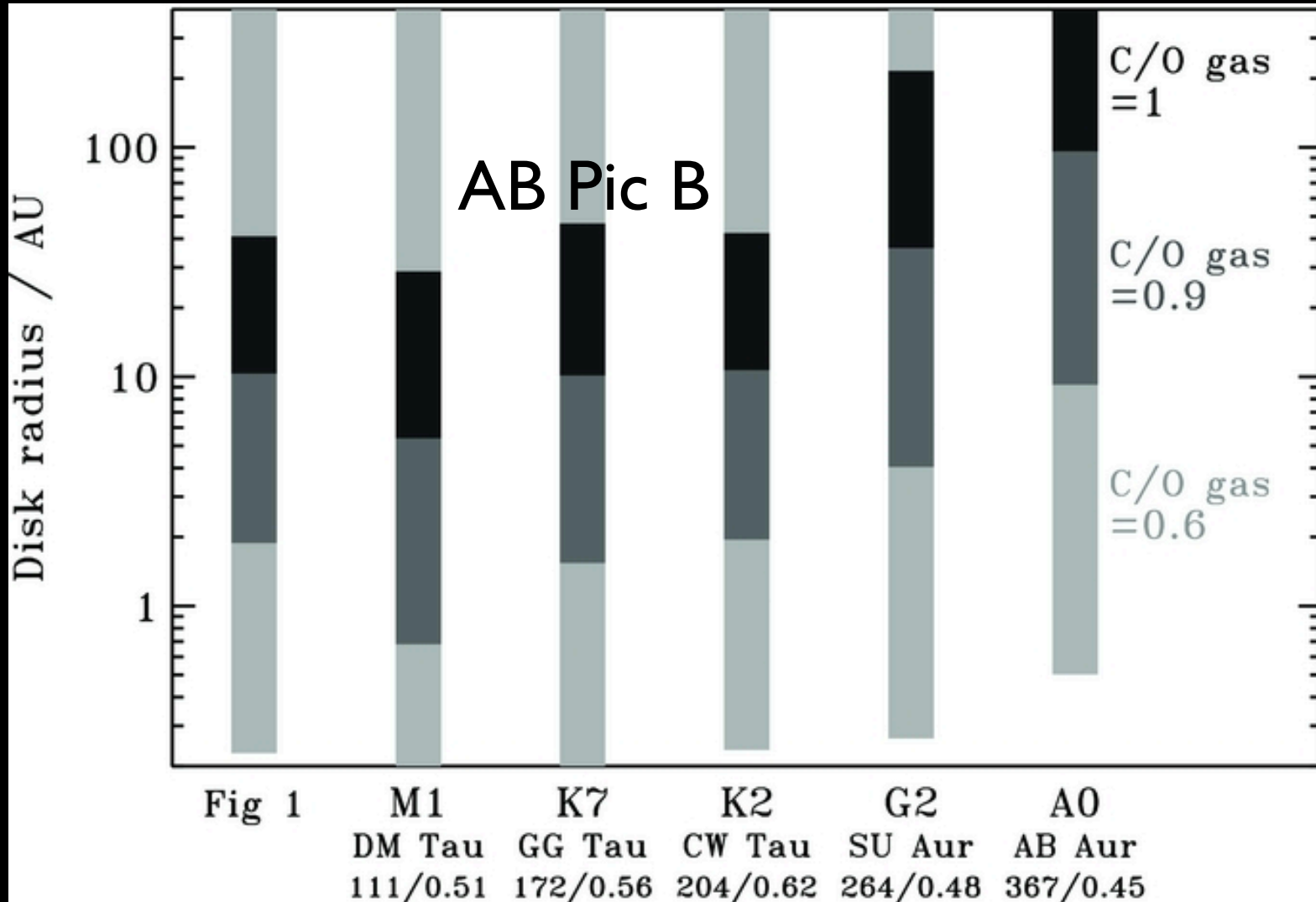


AB Pic B [C/O] = +0.2 (0.85 in linear scale)



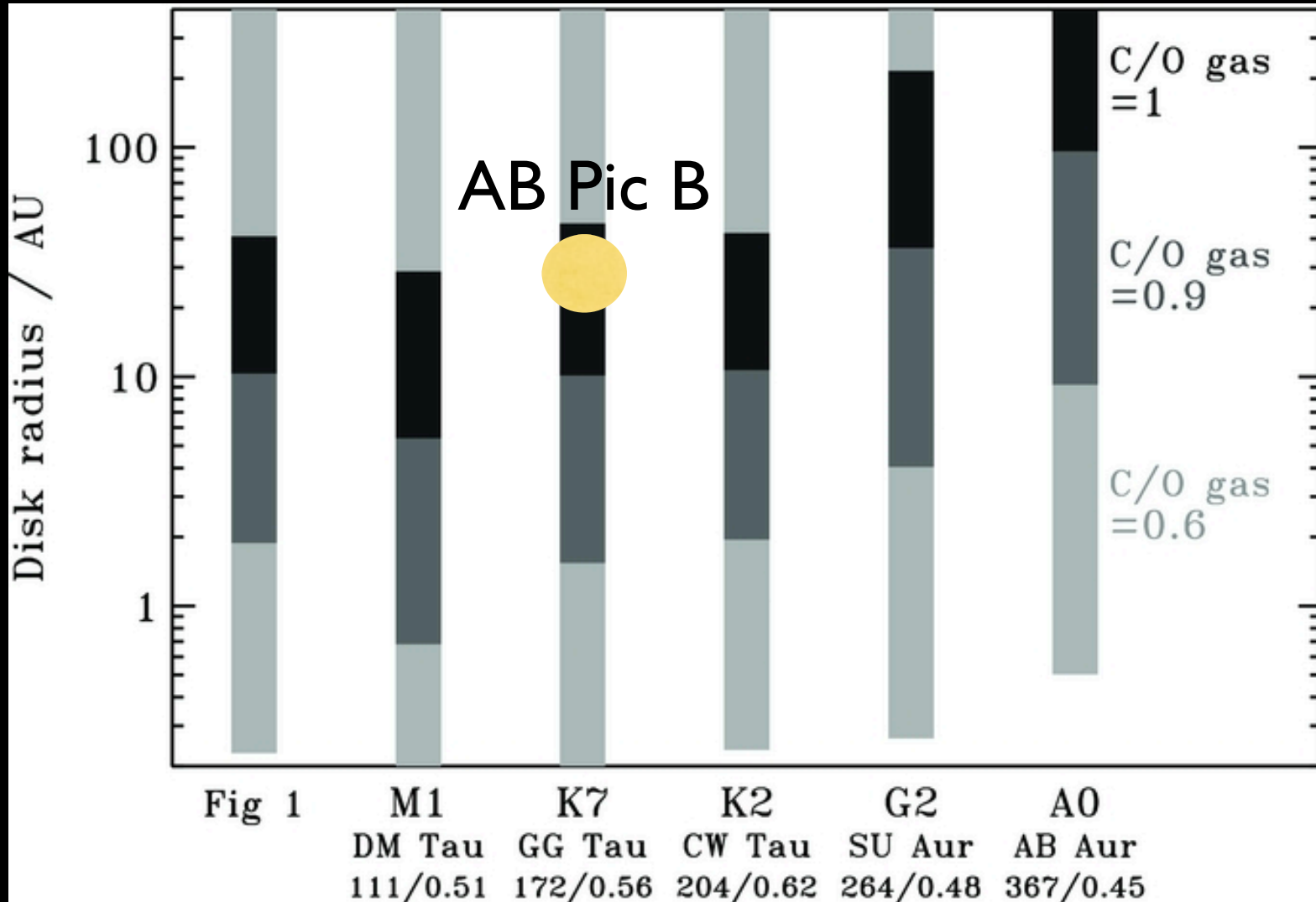
Öberg et al. 2011

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Öberg et al. 2011

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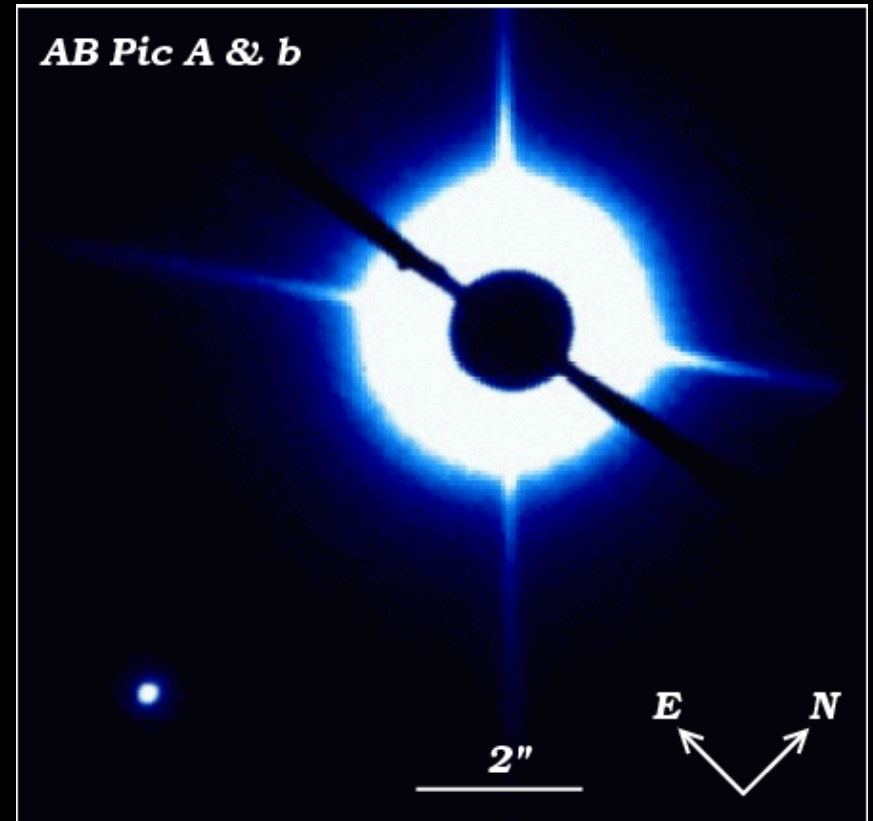


Öberg et al. 2011

AB Pic A+B: **TENTATIVE** conclusions!

- Host: K2V, $T_{\text{eff}}=4800\text{-}5000\text{K}$
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 $T_{\text{eff}}=1600\text{-}1900\text{K}$
 $15M_{\text{Jup}}$ at 275 AU

$[\text{C}/\text{O}] = +0.2$ - formed by
core accretion?



Chauvin et al. (2005)

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Thank you!