Characterization of the low-mass companion HD 142527 B

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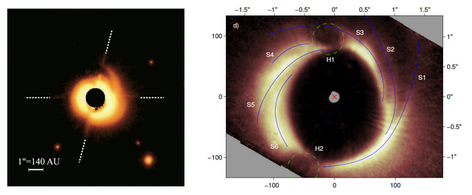
Introduction

HD 142527: Herbig Fe star, ~2 M_{Sun}, 3-5 Myr old, 140 pc

Protoplanetary disk with gap: ideal case-study for planet formation

NIR spiral (Fukagawa+06) | NIR spirals & shadows (Avenhaus+14)

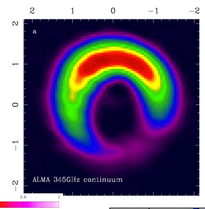
μm dust

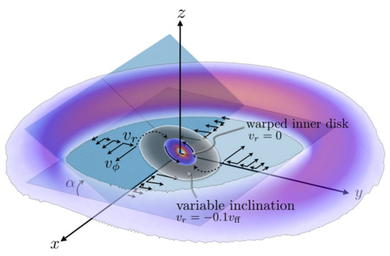


Model

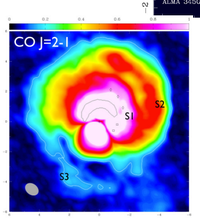
mm dust

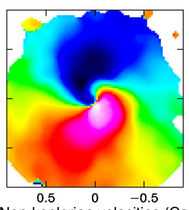
Horseshoe shaped mm-continuum interpreted as dust trap (Casassus+13)





gas

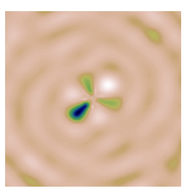




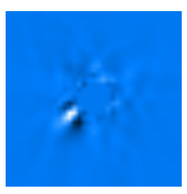
(Casassus+15)

Large scale spirals (Christiaens+14) | Non-keplerian velocities (Casassus+15)

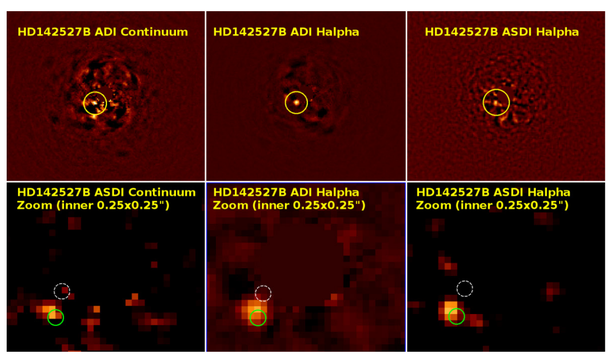
Companion: Detected at ~12au (~0.08") with direct imaging



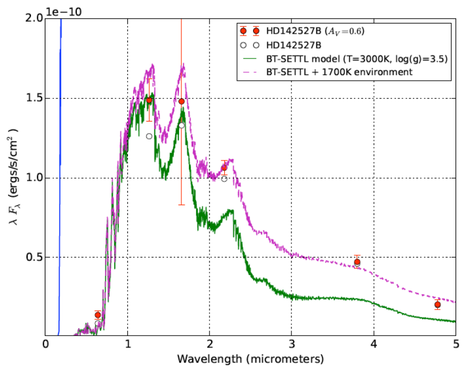
First detection with NACO/SAM (Biller+12)



Confirmation with GPI (Rodigas+14)



Detection of the companion in Halpha: it is accreting (Close+14)



(Lacour+16)

=> SED fitting indicates a ~0.1 M_{Sun} companion and a hot circumsecondary disk (1700K)… but SED fitting alone can lead to degenerate results

Aims: - Find forming planets in the gap
- Better characterize the companion to understand its impact on the disk morphology

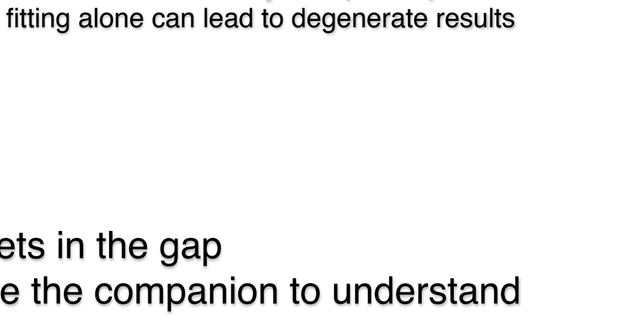
Methods

Instrument: VLT/SINFONI (IFS) in H+K bands

Data: 40 spectral cubes of 1992 channels (~2h integration)

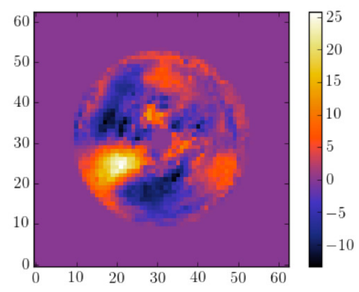
Observation strategy:

pupil-tracking
+
4 points dithering

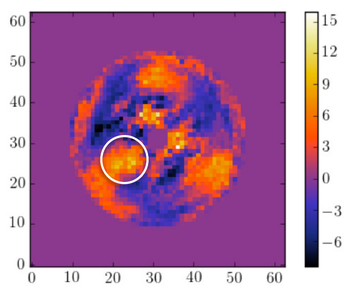


Post-processing:

- Principal Component Analysis applied to Angular Differential Imaging, in each spectral channel
- Negative Fake Companion (NEGFC) technique to estimate the unbiased contrast and position of the companion



Example of PCA-ADI applied on a single channel. Some flux is lost with PCA-ADI though; we use NEGFC to get an unbiased estimate of the flux of the companion.

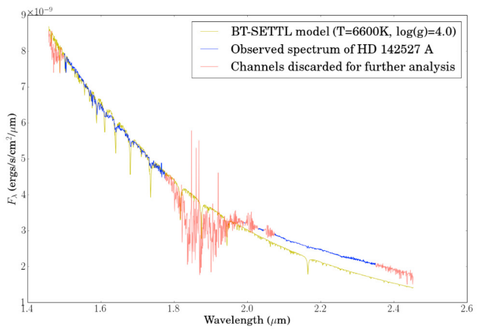


NEGFC injects negative fake companions in the original cube, and minimize the standard deviation in an aperture at the companion location in the final PCA-ADI frame, using a simplex algorithm.

Results

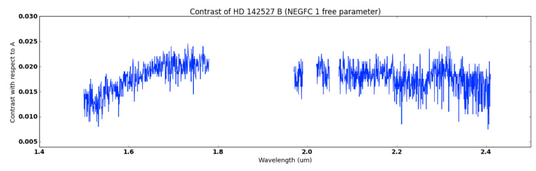
3-5σ re-detection in all channels at the expected location (r~79.6mas; PA~129.6°)

Calibrated spectrum of HD 142527 A



x

NEGFC contrast of the companion



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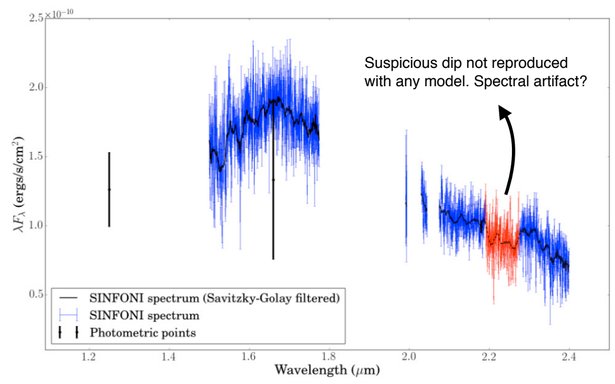
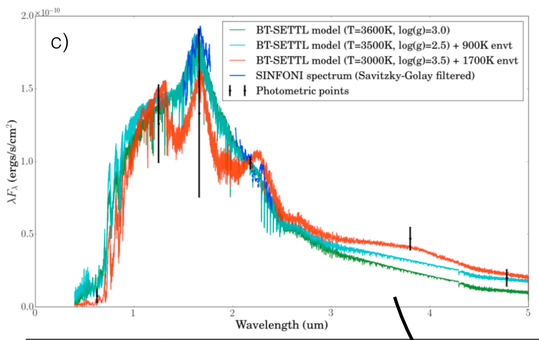
Calibrated spectrum of HD 142527 B



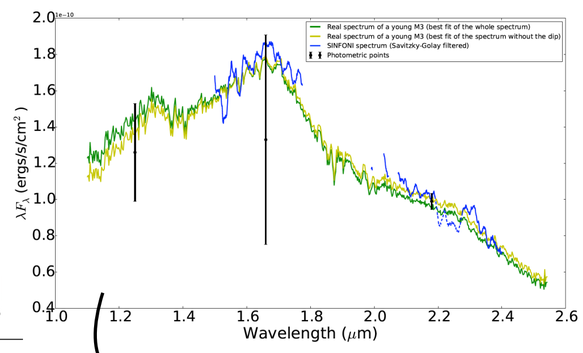
Best fit to BT-SETTL models:



Parameter	Value (whole spectrum fit)	Value (fit excluding the dip)
Companion alone		
T_B [K]	3600 ± 50	3500 ± 50
log(g)	3.0 ± 0.25	3.75 ± 0.25
R_B [$R_\odot$]	0.95 ± 0.03	1.08 ± 0.03
A_H [mag]	0.13 ± 0.04	0.25 ± 0.06
$\chi^{2\dagger}_r$	7.0	5.1
Companion + Disk		
T_B [K]	3600 ± 50	3500 ± 50
log(g)	3.0 ± 0.25	3.75 ± 0.25
R_B [$R_\odot$]	0.96 ± 0.03	1.05 ± 0.03
A_H [mag]	0.15 ± 0.07	0.20 ± 0.07
T_d [K]	600–900	600–900
R_d [$R_\odot$]	2–10	2–10
$\chi^{2\dagger}_r$	7.0	5.1

BT-SETTL best-fit parameters compatible with a PMS M3 dwarf

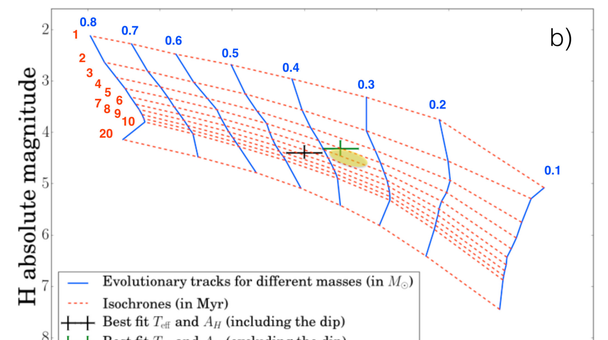
Best fit to template spectra:



best fit obtained with a young M3 dwarf

- Lacour+16 model inconsistent with the SINFONI spectrum
- H+K spectrum: mainly photospheric
- the insertion of a circumsecondary disk helps fitting the L and M points

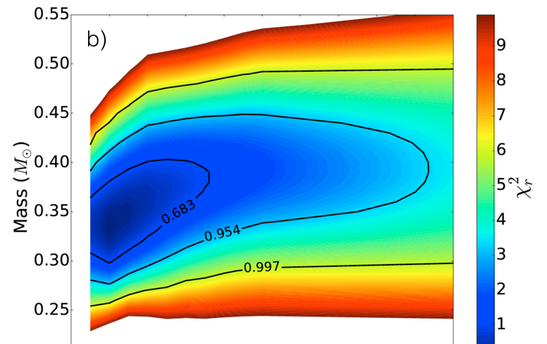
Mass and age estimates:



Average on JHK HR diagrams:

$M \sim 0.37 \pm 0.01 M_\odot$

$\mathrm{Age} \sim 4.5 \pm 1.1 \mathrm{Myr}$



χ^2_r map based on BT-SETTL models with similar TB and log(g)

$M \sim 0.34^{+0.06}_{-0.04} M_\odot$

$\mathrm{Age} \sim 2.5^{+4.5}_{-1.5} \mathrm{Myr}$

Mass accretion rate: $\sim 3 \times 10^{-9}\ \mathrm{M_\odot\ yr^{-1}}$ (1-2% the rate for the primary)

Conclusion

More details in Christiaens+2017, submitted to A&A

- First medium resolution spectrum of a companion at <0.1"
- Spectral fit points towards an M3 dwarf (with T~3500K, log(g)~3.5)
- Age estimate (2-5 Myr) consistent with the age of the primary
- Estimated mass >3x higher than previous one based on SED alone
- The impact of the companion on the disk morphology should be re-evaluated with new hydro-dynamical simulations

Acknowledgements: We acknowledge Gerrit van der Plas, Sylvestre Lacour, Mickaël Bonnefoy, Gregory Herczeg and Jackie Faherty for useful discussions. VC and SC acknowledge support by Millenium Science Initiative (Chilean Ministry of Economy) through grant RC130007. VC acknowledges support from CONICYT through CONICYT-PCHA/Doctorado Nacional/2016-21161112. This research has benefitted from the SpeX Prism Library and its Analysis Toolkit, maintained by Adam Burgasser at http://www.browndwarfs.org/spexprism.