Constrains on the frequency of sub-stellar companions on wide circumbinary orbits

Mariangela Bonavita[1]

& the SPOTS team

[1]Institute for Astronomy, The University of Edinburgh

Why planets in binaries?

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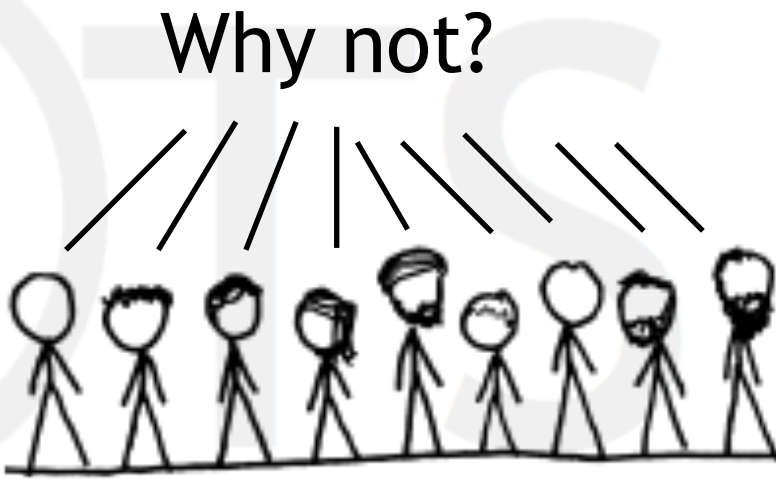

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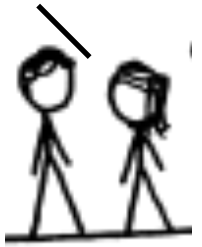
*This doesn't mean there are no binaries in those samples



Bonavita & Desidera (2007)

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  - ✓ ~60% of close (<3 AU) binaries show IR excess rate
- Well suited for detection with Direct Imaging
  - ✓ Unlike RV and Transits, Direct Imaging is mostly sensitive to planets on wide orbits
  - ✓ Few planetary mass companions already imaged so far

The SPOTS survey

First direct imaging survey <u>dedicated to circumbinary planets</u>

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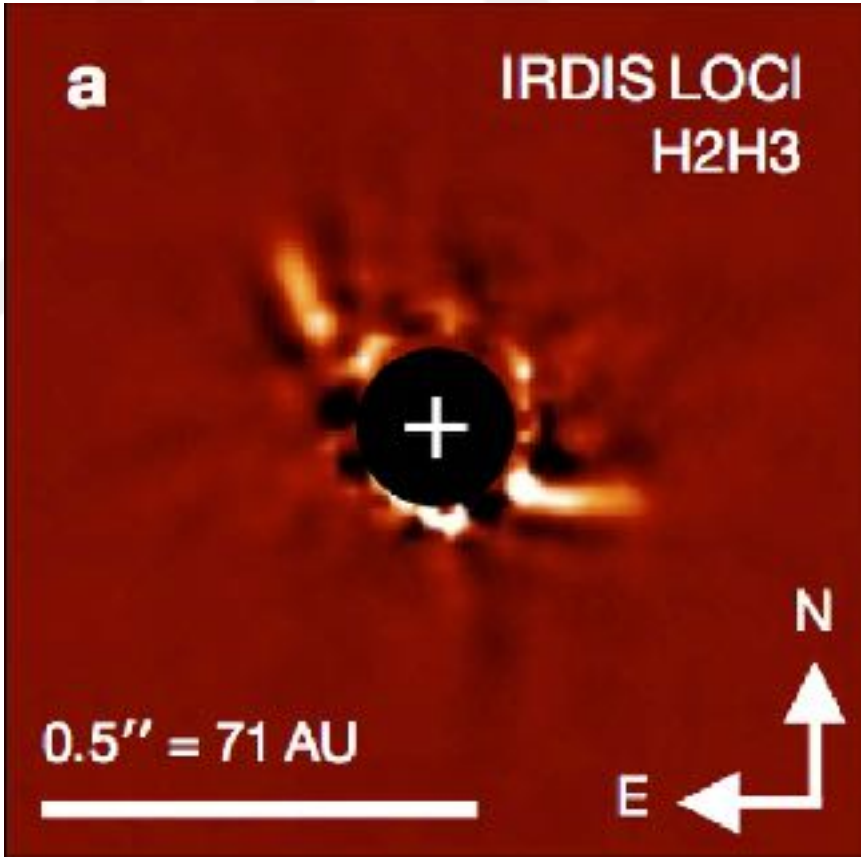
  - ✓ 1 resolved circumbinary disk (AK Sco, see Janson et al 2016)



Waiting for SPOTS

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Bonavita et al. 2016

SPOTS archive survey

- Circumbinary (CBIN) Sample
  - 24 Published Direct Imaging Surveys

Table 1. Characteristics of the surveys considered to build the **circumbinary (CBIN) sample. Both** the **total number** of **targets** included **in each survey** (N_{S_*}) **and** the **number of stars considered** in **our study** (N_{CBIN}) are **reported.**

Source	Instrument	Technique	Filter	N_{S_*}	N_{CBIN}	Reference
L05	HST/NICMOS	COR	H(1.4-1.8)	45	6	Lowrance et al. (2005)
B06	VLT/NACO	COR	K_S/H	17	3	Brandeker et al. (2006)
B07	VLT-NACO/MMT	SDI	H	45	7	Biller et al. (2007)
K07	VLT/NACO	DI	L	22	4	Kasper et al. (2007)
GDPS	GEMINI/NIRI	SDI	H	85	8	Lafrenière et al. (2007)
CH10	VLT/NACO	COR	H/K_S	91	9	Chauvin et al. (2010)
H10	Clio/MMT	ADI	L'/M	54	3	Heinze et al. (2010)
JH11	GEMINI/NIRI	ADI	K/H	18	3	Janson et al. (2011)
JJ12	VLT/NACO	DI	K_S	1	1	Joergens et al. (2012)
V12	VLT/NACO, NIRI	ADI	K_S/H'/CH4	42	3	Vigan et al. (2012)
R13	VLT/NACO	ADI	L'	59	3	Rameau et al. (2013b)
B13	SUBARU/HiCiao	DI/ADI/PDI	H	63	6	Brandt et al. (2014a)
J13	SUBARU/HiCiao	ADI	H	50	4	Janson et al. (2013a)
Y13	SUBARU/HiCiao	ADI	H/K_S	90	3	Yamamoto et al. (2013)
N13	GEMINI/NICI	ADI/ASDI	H	70	4	Nielsen et al. (2013)
BN13	GEMINI/NICI	ADI/ASDI	H	80	4	Biller et al. (2013)
JL13	GEMINI/NICI	DI/ADI	K_S	138	5	Janson et al. (2013b)
L14	GEMINI/NIRI	DI/ADI	K_S	91	18	Lafrenière et al. (2014)
SONG	HST	ADI	H	116	14	Song et al. priv. comm.
M14	VLT/NACO	ASDI	H	16	1	Maire et al. (2014)
NLP	VLT/NACO	DI/ADI	H	110	8	Chauvin et al. (2015)
D15	GEMINI/NIRI	DI	K_S	64	4	Daemgen et al. (2015)
B15	SUBARU/HiCiAO	DI/ADI	K_S	31	5	Bowler et al. (2015)
	KECK/NIRC2/N	DI/ADI	H	59	3	
L15	VLT/NACO	ADI	L'	58	10	Larnier et al. 2016 (submitted)

Techniques: **COR** = Coronagraphy; **SDI** = Spectral Differential Imaging; **DI** = Direct Imaging; **ADI** = Angular Differential Imaging; **PDI** = Polarized Differential Imaging; **ASDI** = Angular and Spectral Differential Imaging

SPOTS archive survey

- Circumbinary (CBIN) Sample
  - 24 Published Direct Imaging Surveys
  - 117 Systems
    - ✓86 binaries
    - ✓31 higher order multiples
  - 5 Detections
    - ✓2 planetary mass companions
    - ✓3 low-mass brown dwarfs

Name	Mass	Separation
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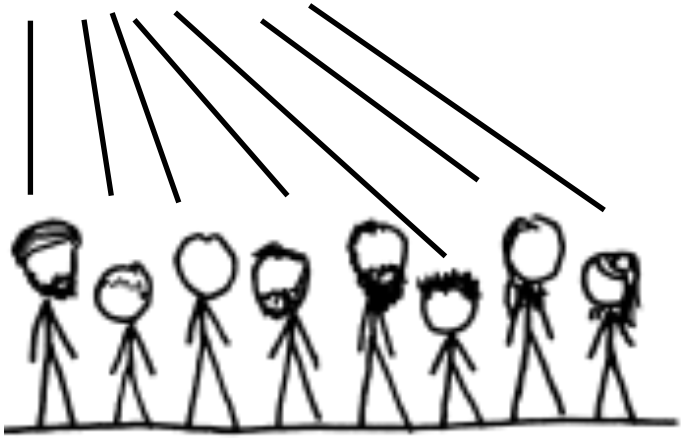

Because I wanted to publish!

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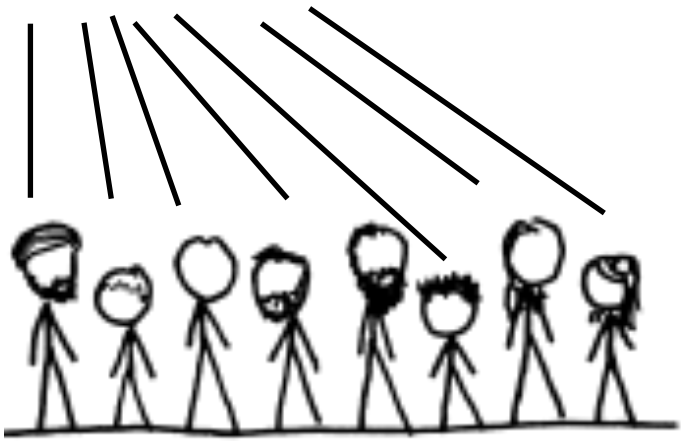
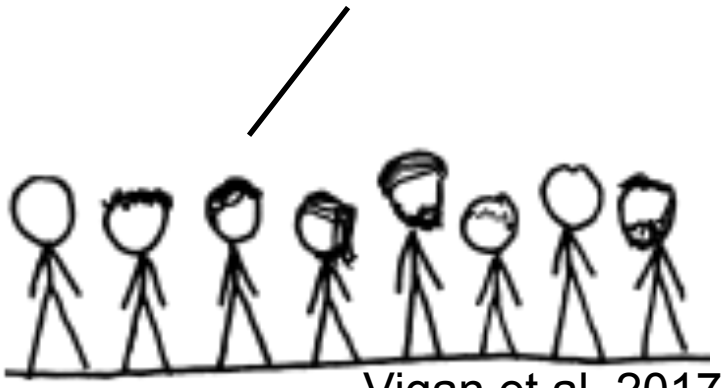


We actually did it in the end…



Vigan et al. 2017

SPOTS archive survey

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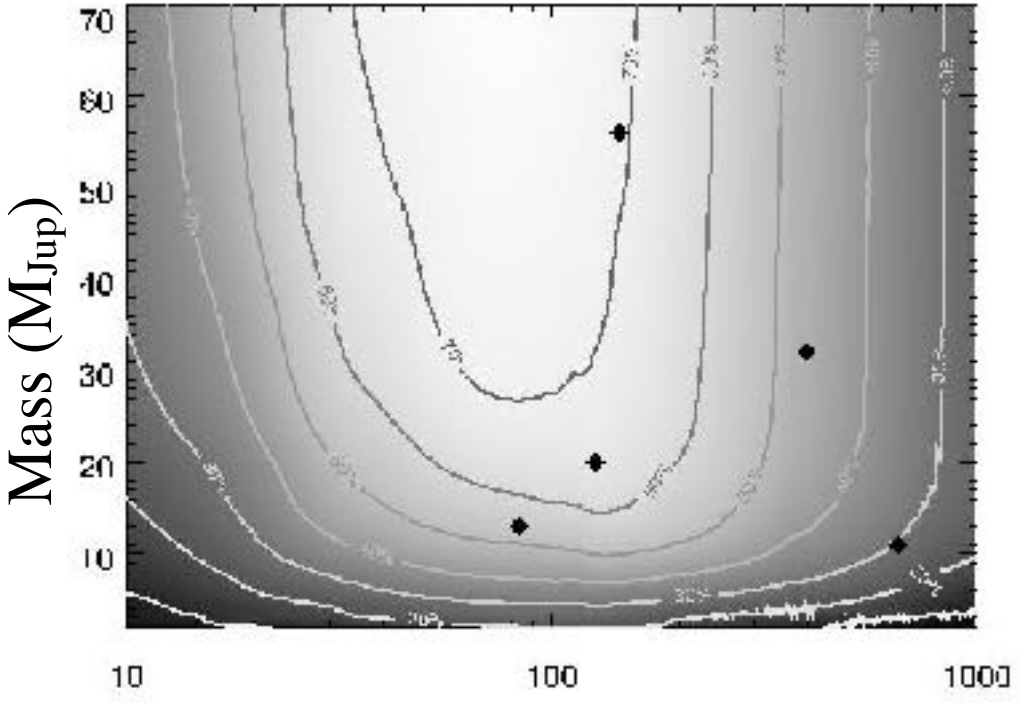

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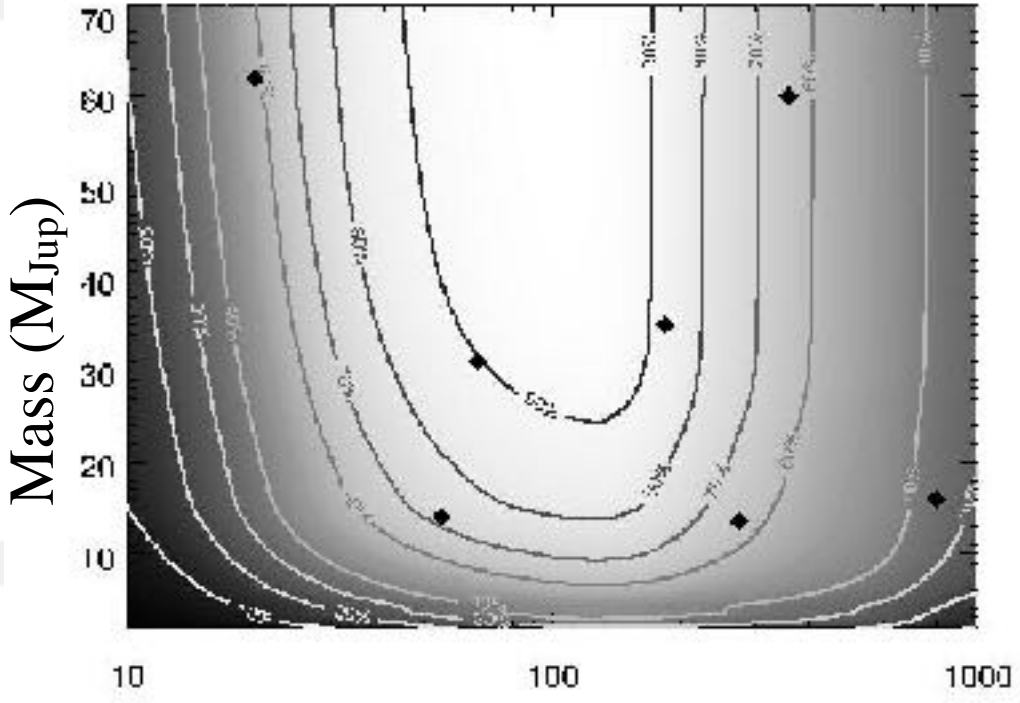

*Q-MESS code, Bonavita et al. 2013

SPOTS archive survey

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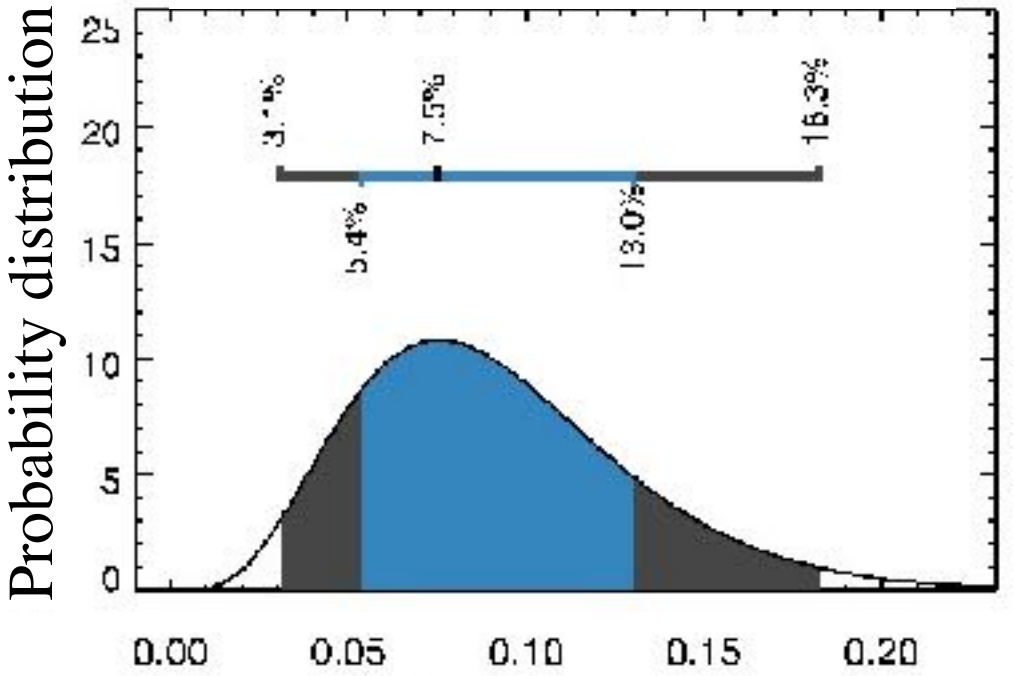

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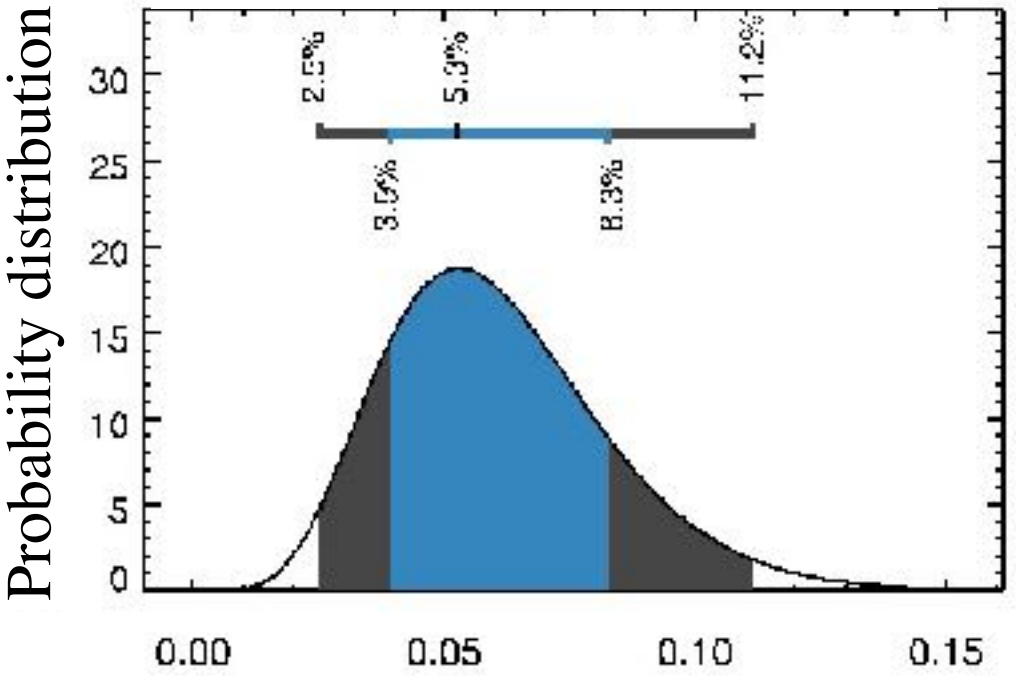

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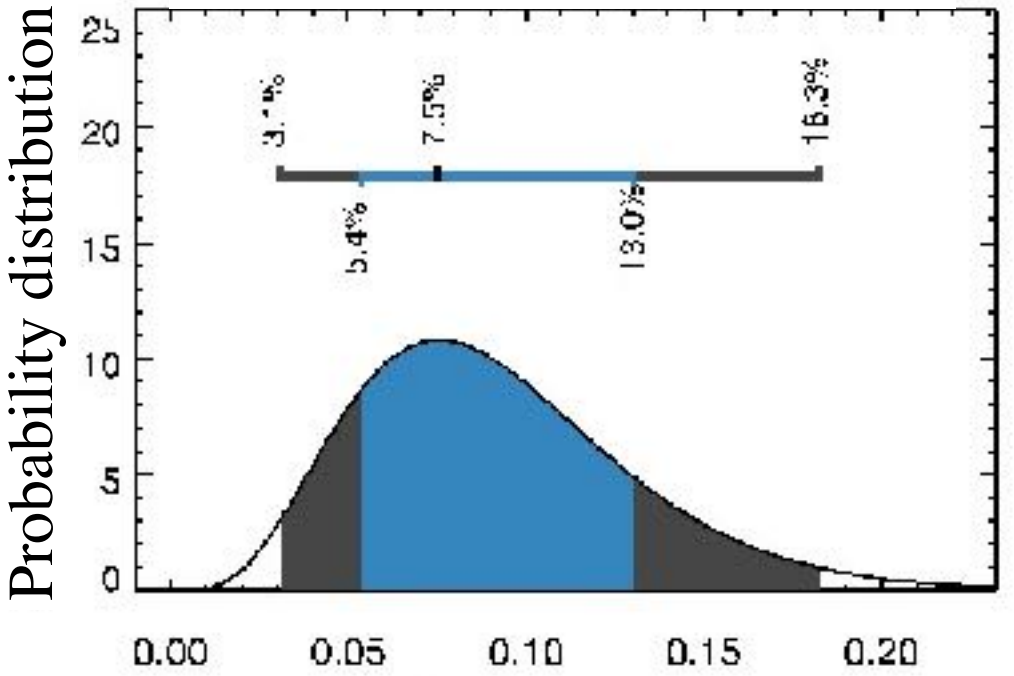

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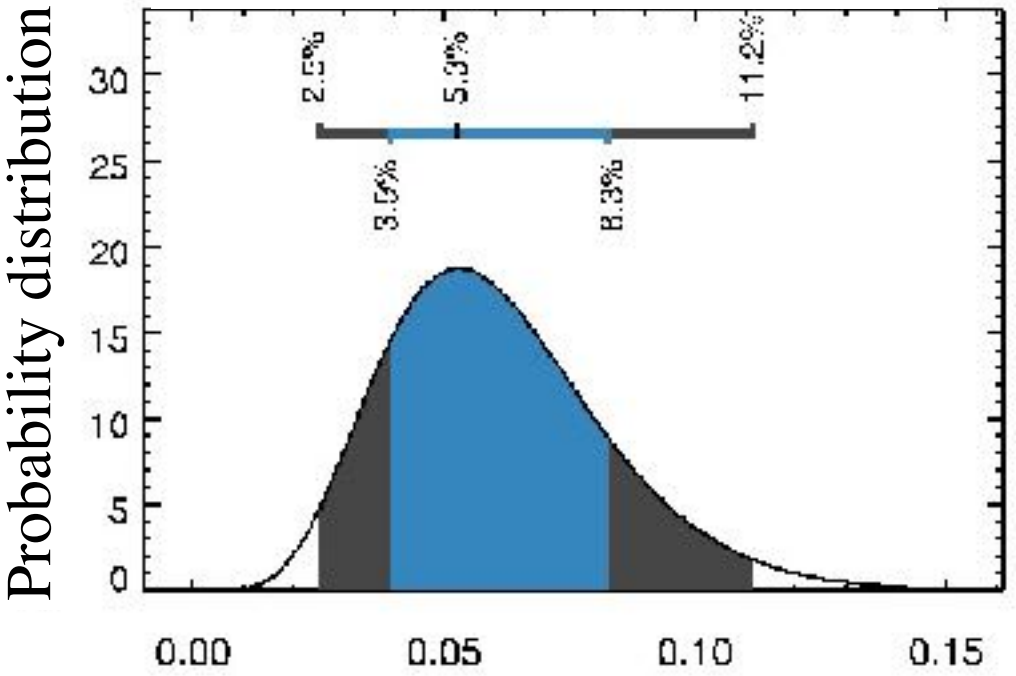

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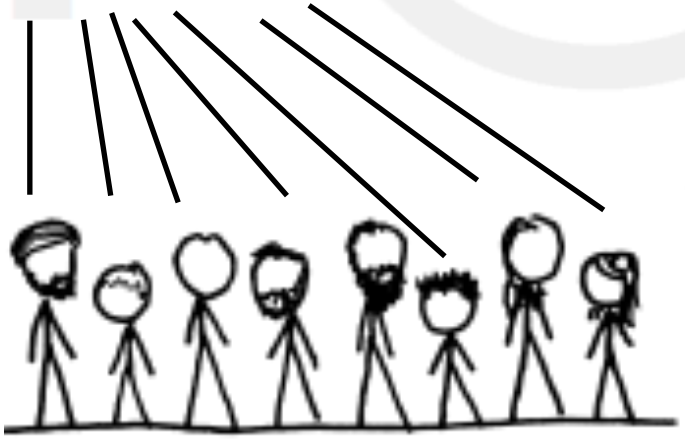
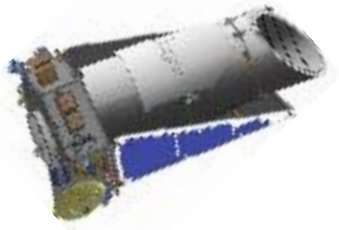


SPOTS VS 

- Our sample includes binaries similar to those targeted by Kepler but:
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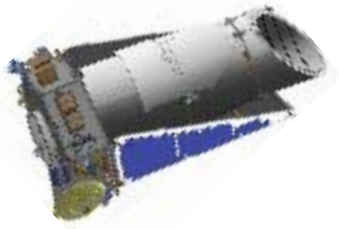
SPOTS VS 

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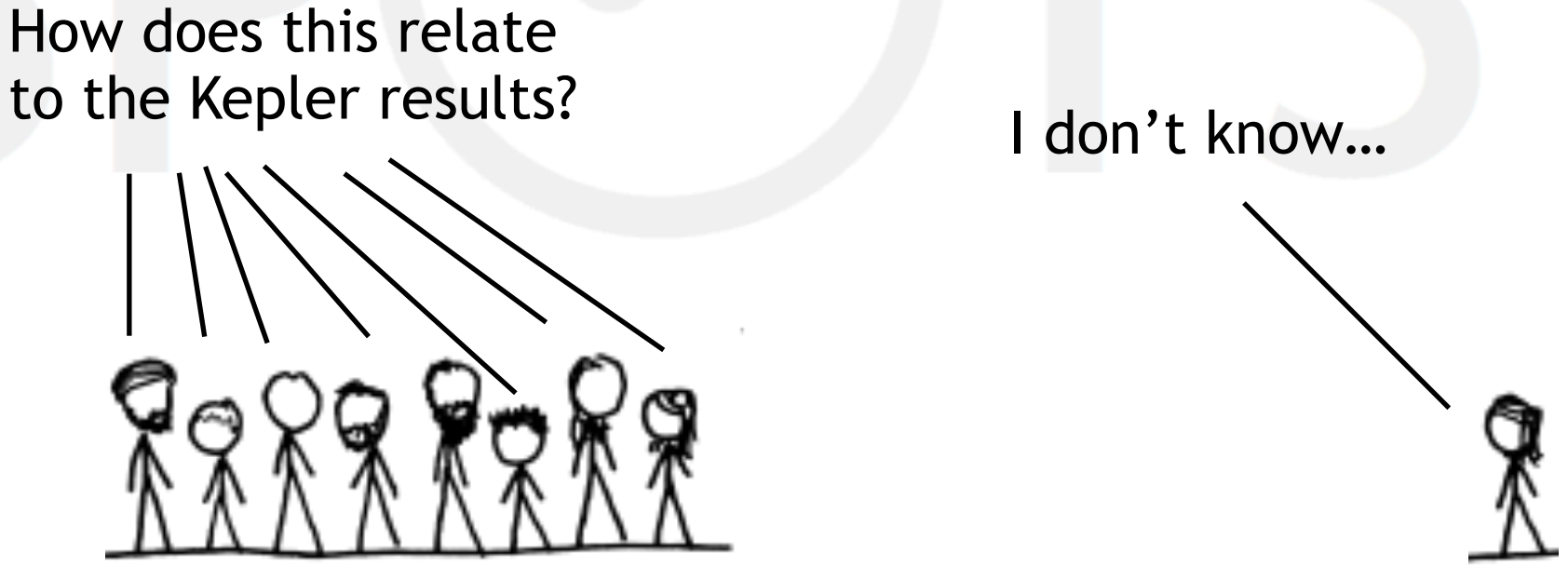
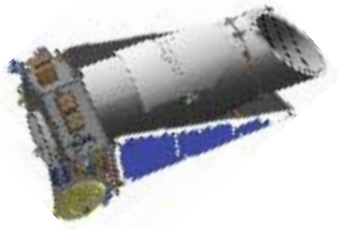


SPOTS VS 

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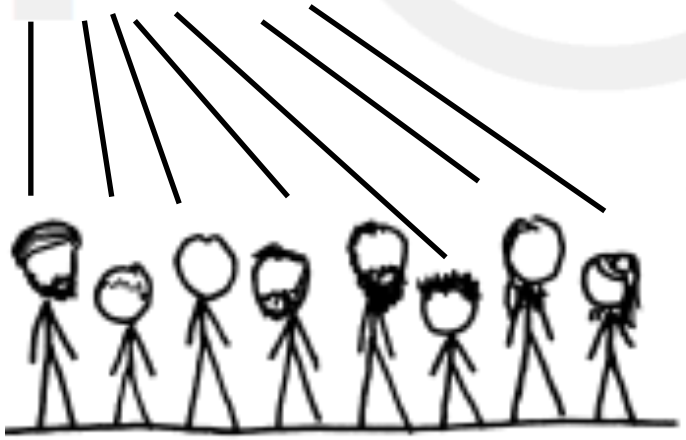

We need more data!

Conclusions

There's no strong difference, in terms of the frequency of wide sub-stellar companions, between close binaries and single stars

Further information is needed to clarify whether the DI circumbinary planets and the Kepler ones belong to different populations

Bonavita et al. 2016

This is the SPOTS team

They look at binary stars to find planets

The SPOTS team members are brave

Be like the SPOTS team