Detection of gaps in protoplanetary disks with PEGASE and DARWIN

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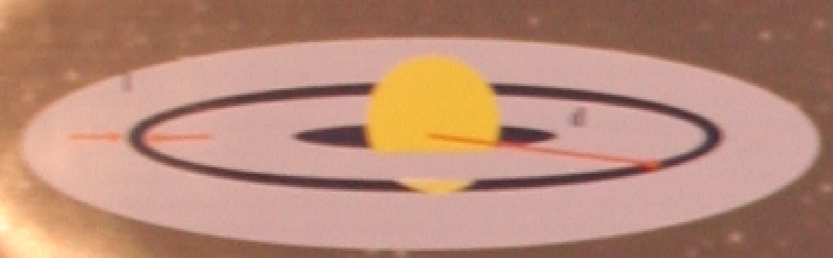
Abstract : DARWIN and PEGASE are two projects of infrared (thermal and near respectively) space interferometer aiming to detect and characterize exoplanets and to improve the understanding of planet formation mechanisms. Recent hydrodynamical studies have shown that sufficiently massive planets are able to open gaps in protoplanetary disks (BRYDEN *et al.*, KLEY *et al.*). The detection of such gaps would offer new clues for understanding organic relationship between disks and planets but also provide a mean to indirectly detect the presence of massive planet. In this poster, we present an original method of gap detection using constructive interferometry and taking full advantage of the spectral resolution of both interferomters and we will explore the modulation of spectral visibility curves induced by protoplanetary disks owning gaps. Based on the standard parameterized disk model, we identify gap and disk parameter ranges for which PEGASE and DARWIN would be able to detect gaps. Afterwards, we performed more realistic gap models in order to confirm gap detectability.

Keywords : gaps, protoplanetary disks, optical interferometry, DARWIN, PEGASE.

Simple gap model in a standard accretion disk :



Gap parameters :

d : distance to the star

l : gap width

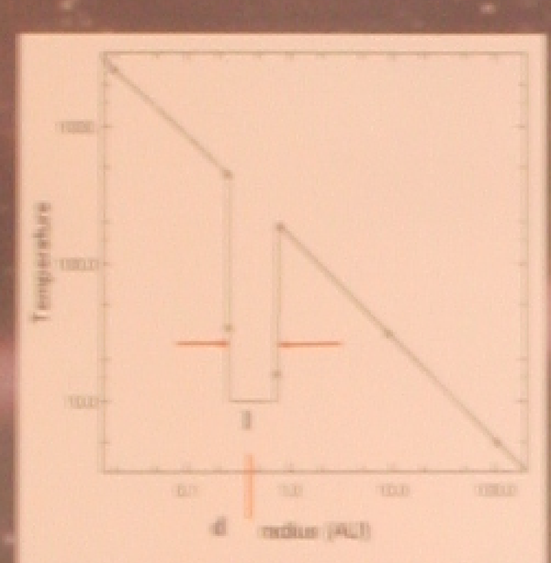


Fig. 1 : Toy-model of a gap developed from standard accretion disk where the temperature is supposed to follow a power law. We modelized the gap by a drop in the temperature profile. We fixed the bottom of the gap at a temperature of 10 K [illegible] while the gap width corresponds to a Roche radius which corresponds to the influence region of the planet.

Gap detection using spectro-interferometry :

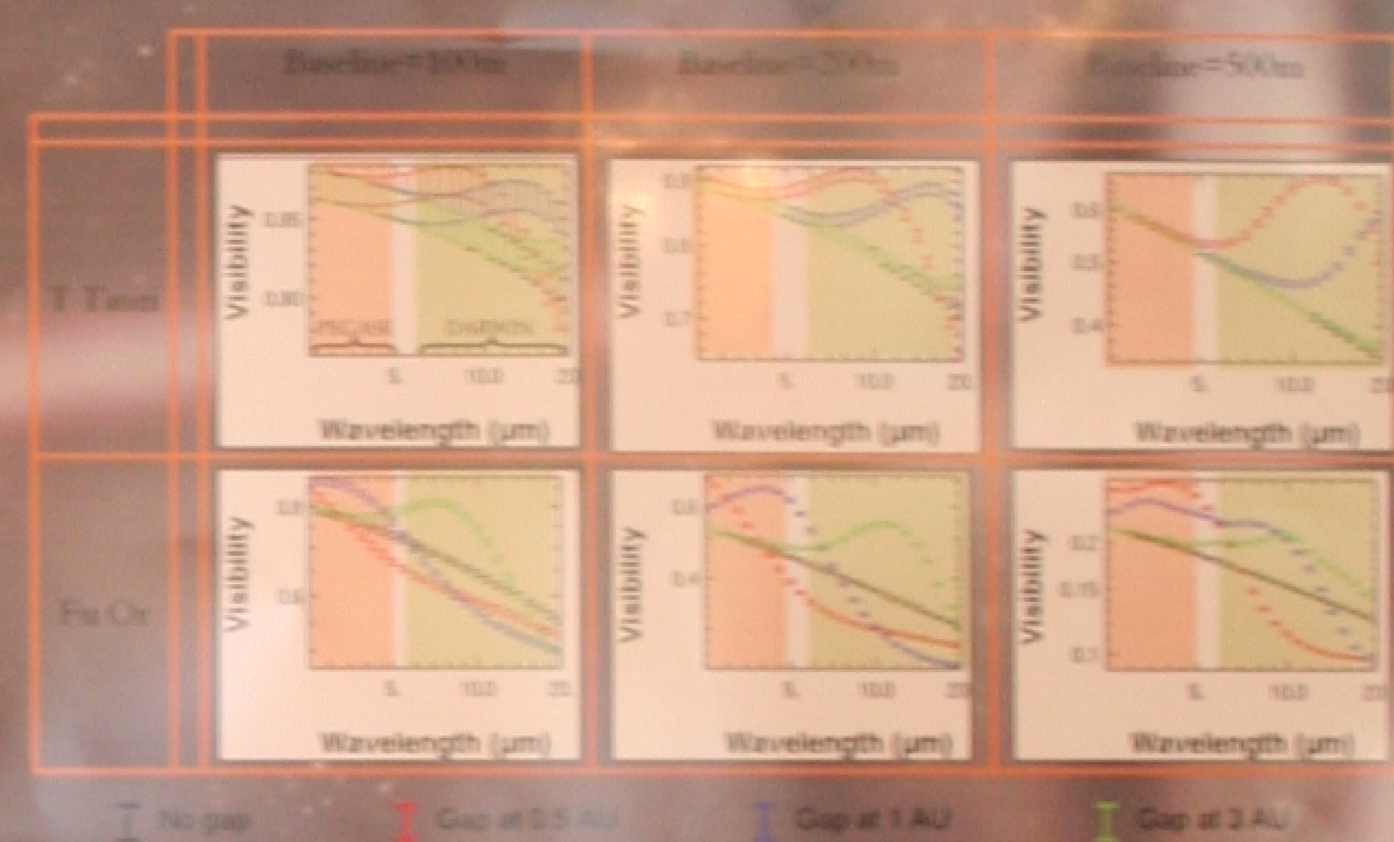


Fig. 2 : While gap detections using classical visibilities require a large uv-coverage and a good accuracy on visibility measurements (better than 1 %), the study of visibilities versus the wavelength allow to detect gaps with only a few visibility measurements and to distinguish different gap distances. The longer the baseline is, the more obvious the detection is. Due to the brighter disks exhibited by Fu Or stars, gaps induce larger modulation than in the case of classical T Tauri stars.

Gap detectability in short :

	PEGASE	DARWIN
		
Spectral coverage	2.5-5 μm	6-20 μm
Spectral resolution	60	20
Angular resolution	→ ~0.3 mas (B=500m, λ=2.5 μm)	→ ~0.9 mas (B=500m, λ=6 μm)
Accuracy on visibility measurements	1%	1%
Gap detectability by spectro-interferometry	0.25 → 2 AU	0.5 → 8-12 AU

Tab. 1 : Overview of PEGASE and DARWIN missions. Range of detectable gap distance taking full advantage of the spectral resolution of both interferometers.

A more realistic modeling :

Fig. 3 : Overview of the surface density profile for disk with gap [illegible] (VARNIERE *et al.*) and for disk without gap. Images of disk with and without gaps [illegible] are produced injecting surface density profile in a 3D radiative transfer code, MCFOST [illegible]. Visibility versus wavelength [illegible] disk with gap in red, disk without gap in black.

Conclusions :

- Gaps seem to be detectable using spectro-interferometry, very long baselines (200-500 m)
- Non-nulling interferometric mode allows also to carry interesting science

Perspectives :

- Developing scientific tools to help extracting gap signatures out of spectral-visibilities
- Gap detection would be an essential tool to challenge planet formation theories
- PEGASE and DARWIN would complementary clues with respect to ALMA (WOLF *et al.*)

References :

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