



Report from the event
supported by RadioNet

TITLE *PLANET-FORMING DISKS – A WORKSHOP TO HONOR ANTONELLA NATTA*

DATE: *MARCH 4-8, 2019*

LOCATION: *VILLA VIGONI, MENAGGIO, ITALY*

MEETING WEBPAGE: *<http://www.mpia.de/homes/planetformingdisks/index.html>*

HOST INSTITUTE:

**RADIONET
BENEFICIARY / NO:** *DIAS/16*

Report:

1. SCIENTIFIC SUMMARY

Although several thousand exoplanets have been detected, little is known about the planet formation process and the initial stages of planet evolution, in particular due to the lack of strong observational constraints. Protoplanetary disks allow us to study planet formation while it is happening, granting us the opportunity to witness the interaction of a protoplanet with its environment. Recent ALMA observations at unprecedented angular resolution show that substructures are ubiquitous in disks. These substructures appear in continuum images as rings, lopsided asymmetries, and in a few cases, spiral arms and are strong indications of on-going planet-disk interaction. Nevertheless, the quest for protoplanets embedded in their host disk through direct imaging has been extremely challenging, with various claimed candidates so far unconfirmed.

The aim of this workshop was to bring together the experts from various fields related to young stellar and planetary systems from both, observational and theoretical point of view, in order to address the still open questions regarding the planet formation and disk evolution processes in protoplanetary disks.

During the workshop most recent results on mass transport processes, in particular stellar accretion and disk winds/jets were presented and discussed in the context of disk evolution processes (Monday afternoon & Tuesday morning). The workshop addressed in detail the analysis of protoplanetary disk, from the characterization of the innermost disk regions - a key zone for understanding the transport of angular momentum within, as well as the energy balance of the disk - to the analysis of substructures observed in recent high-angular resolution surveys in the sub-mm as well as in the near-infrared regime (Tuesday afternoon & Wednesday morning). Those substructures were in particular discussed to be primary tracers for the presence of forming planets within these disks. This was evidenced by the presentation of kinematical detections of embedded protoplanets using sub-mm molecular line observations (Thursday morning), as well as of the direct detection of a protoplanet in the near-infrared within protoplanetary disks showing evidence of substructures. Finally, the workshop addressed the properties of brown dwarfs (Thursday afternoon) and young planets, in particular their rotation, variability, accretion disks and the theory of accretion and migration processes, as well as the formation mechanisms of planets (Friday morning).

The highlights of the events are presented in Figure 1, 2 and 3. Figure 1 shows the results of the Disk Substructures at High Angular Resolution Project (DSHARP) which was the first ALMA Large Program on protoplanetary disks. This program led to the discoveries of many substructures in disks with a wide range of stellar/disk properties. Results from DSHARP and other surveys (Taurus) were presented by J. Huang, L. Perez, A. Isella, and F. Long. Figure 2 shows the detection of an embedded planet in a protoplanetary disk by the use of the kinematic field of the CO molecular tracer. Studies of kinematic perturbations were presented by C. Pinte and R. Teague. Figure 3 shows the models that show that multiple disk substructures can be due to a single planet in a low viscosity disk. Such models were presented by J. Bae.

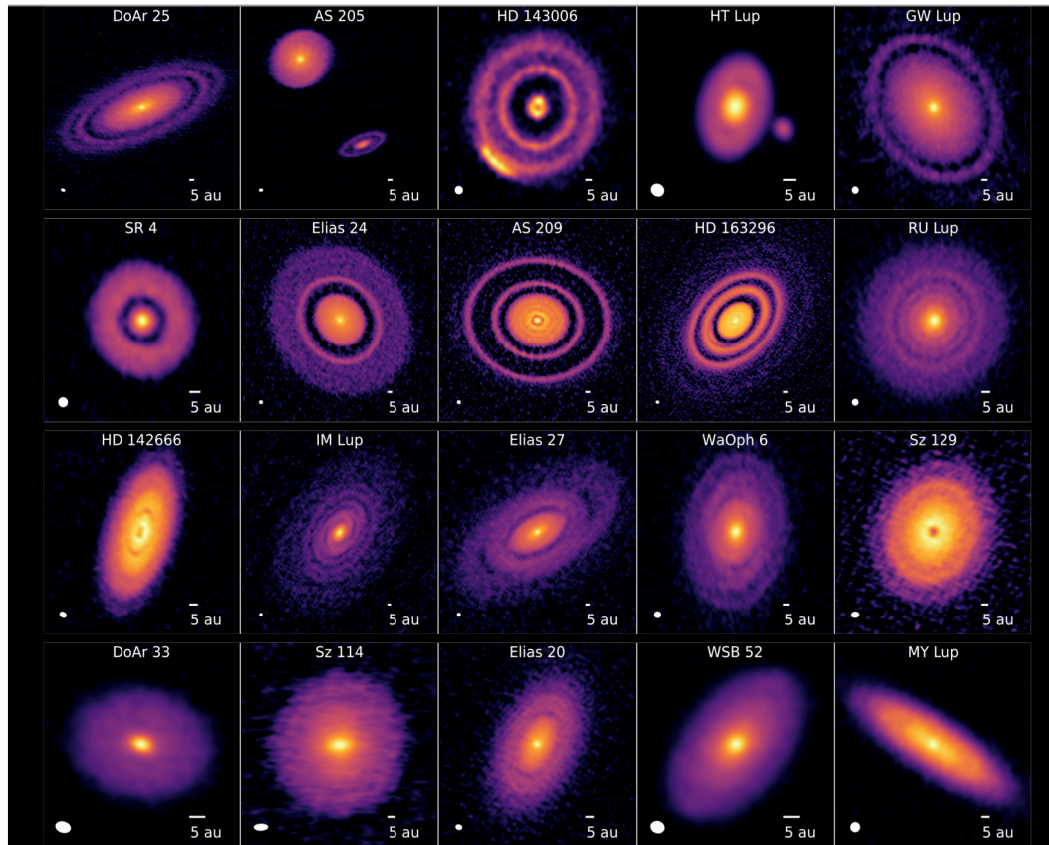


Figure 1 Results from the DSHARP survey: 20 protoplanetary disks observed at high-angular resolution with ALMA showing a ubiquitous presence of substructures suggestive for the presence of forming planets. *Presented by J. Huang, L. Perez, A. Isella.*

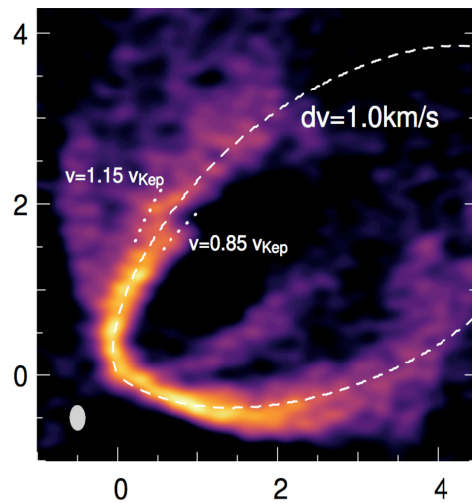
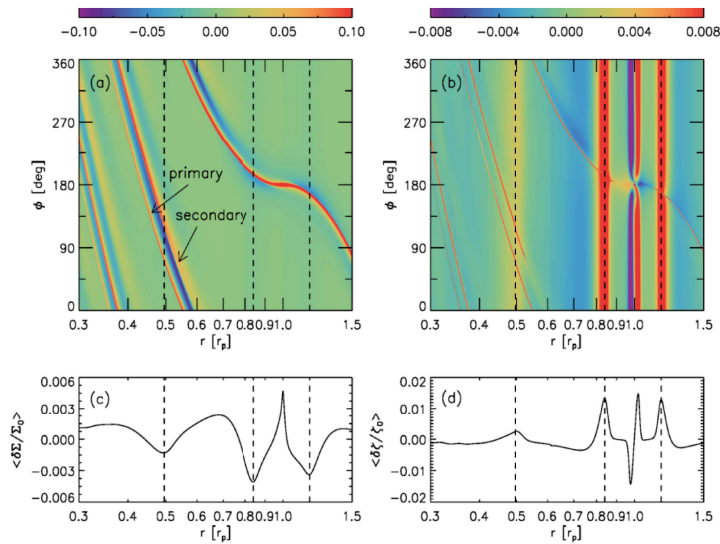


Figure 2 Kinematic detection of an embedded protoplanet within the protoplanetary disk HD163296. The image shows distortion in the CO channel maps caused by the kinematic effect of the planet on the disk velocity pattern. *Presented by C. Pinte and R. Teague.*

Figure 3 Hydrodynamical simulations using a migrating Neptune mass planet in a disk. Such a planet leads to the formation of multiple rings and gaps in a low viscosity disk. *Presented by J.Bae.*

The workshop had extensive discussions about millimeter observations, and many mentions of observations obtained with ALMA, APEX and IRAM.

The event has had a large impact on the RadioNet community, and was very appreciated by all participants who perceived it as the best and highest quality conference on protoplanetary disks in years. Not only new collaborations have started but already a first paper triggered by the discussions at the workshop has been submitted to ApJ (Zhu et al. 2019, “One Solution to the Mass Budget Problem for Planet Formation: Optically Thick Disks with Dust Scattering”).

The conference webpage is : <http://www.mpia.de/homes/planetformingdisks/index.html>

In the webpage, we also have a booklet with the program & abstracts as well as most of the pdf online: <http://www.mpia.de/homes/planetformingdisks/program.html>

2 Agenda of the event

Monday March 4:

12:30 - 14:00 Lunch

14:00 - 14:30 Introduction to the workshop - *L. Testi*

Session I. Accretion & Ejection - Chair: D. Galli

14:30 - 15:00 Measuring mass accretion rates to better understand how protoplanetary disks evolve - *C. Manara*

15:00 - 15:30 Disc evolution processes: a phenomenological view - *G. Rosotti*

15:30 - 16:00 Low velocity winds: what we know and what they are telling us on the disk dispersal - *E. Rigliaco*

16:00 - 16:30 Coffee break

16:30 - 17:00 The role of disc photoevaporation on disc dispersal and the formation and evolution of planets - *B. Ercolano*

17:00 - 17:15 The dimming events of RW Aur A - *M. Koutoulaki*

17:15 - 17:30 Massive protostellar jets as a tool of ejection and accretion processes in HMYSOs - *R. Fedriani*

17:30 - 18:15 Discussion: accretion - N. Calvet & L. Hillenbrand

Tuesday March 5:

Chair: R. Alexander

9:15 - 9:45 Unveiling the secrets of inner disk winds from a detailed kinematic survey of [OI] optical lines - *A. Banzatti*

9:45 - 10:15 Gone with the wind: News from magnetic driven wind models of protoplanetary disks - *M. Flock*

10:15 - 10:45 The innermost structure of protoplanetary disks - *R. Garcia Lopez*

10:45 - 11:15 Coffee break

11:15 - 12:00 Discussion: ejection - C. Dougados & F. Bacciotti

Session II. Disk demographics, substructures & dust evolution

12:00 - 12:30 The Demographics of Planet-forming Disks - *I. Pascucci*

12:30 - 13:00 Measuring protoplanetary discs' sizes with ALMA - *M. Tazzari*

13:00 - 14:30 Lunch

Chair: R. van Boekel

14:30 - 15:00 From Disks to Rings - Dust Evolution in the ALMA Era - *T. Birnstiel*

15:00 - 15:15 Measuring vertical settling and radial drift of dust grains: an ALMA survey of young edge-on disks - *M. Villenave*

15:15 - 15:45 Measuring the grain size and finding the magnetic fields by ALMA polarization - A. Kataoka

15:45 - 16:00 An Introduction to the Disk Substructures at High Angular Resolution Project - J. Huang

16:00 - 16:30 Coffee break

16:30 - 17:00 Results of the Disk Substructure at High Angular Resolution Project - *L. Pérez*

17:00 - 17:15 An ALMA survey of disk structures in Taurus - *F. Long*
17:15 - 18:00 Discussion: disk demographics & grain growth - *F. Ménard & J. Williams*

Wednesday March 6:

Chair: G. Lodato

9:00 - 9:30 Scattered light imaging and the structure of disks - *C. Dominik*
9:30 - 9:45 Evolution of protoplanetary disks from their taxonomy in scattered light
- *A. Garufi*
9:45 - 10:15 Planet-driven spiral waves in protoplanetary disks - *J. Bae*
10:15 - 10:30 Where do the spirals come from? A multi-wavelength high-resolution study of HD 135344B - *P. Cazzoletti*
10:30 - 11:00 Coffee break
11:00 - 11:30 Accreting Circumplanetary Region and its Observational Signatures - *Z. Zhu*
11:30 - 12:00 The interplay between inner and outer disk in misaligned systems - *S. Facchini*
12:00 - 12:30 The role of gravitational instabilities on disc evolution and star & planet formation
- *F. Meru*
12:30 - 13:15 Discussion: substructures - *L. Hartmann & A. Isella*
13:15 - 14:30 Lunch
Free afternoon.

Thursday March 7:

Session III. Molecular Emission from Disks Chair: P. Caselli

9:30 - 10:00 ALMA disk surveys: what does CO tell us about? - *A. Miotello*
10:00 - 10:30 Kinematic detection of embedded protoplanets in circumstellar discs - *C. Pinte*
10:30 - 11:00 Unveiling the dynamics of planet formation - *R. Teague*
11:00 - 11:30 Coffee break
11:30 - 12:00 Probing the composition of the planet-building reservoir in protoplanetary disks: what we have learned from comets and ALMA - *C. Walsh*
12:00 - 12:45 Discussion: chemistry - *T. Bergin & E. van Dishoeck*
12:45 - 14:30 Lunch

Session IV. Planet formation in low mass objects Chair: J. Alcalá

14:30 - 15:00 Accretion and winds of young brown dwarfs - *G. Herczeg*
15:00 - 15:30 Watching brown dwarfs go round and round: Rotation and variability from stars to planets - *A. Scholz*
15:30 - 16:00 Properties of disks around young brown dwarfs and very low mass stars - *L. Ricci*
16:00 - 16:30 Coffee break
16:30 - 16:45 Results on an ALMA survey of disks around Brown Dwarfs - *E. Sanchis Melchor*
16:45 - 17:15 First steps of planet formation around very low mass stars - *P. Pinilla*
17:15 - 18:00 Discussion: brown dwarfs disks - *C. Clarke & J. Bouvier*

Friday March 8:

Session V. From disks to planets Chair: R. Waters

9:00 - 9:30 Close-in Super-Earths: In Situ Formation and Evolution in MRI-active Disks
- *S. Mohanty*
9:30 - 10:00 Formation and migration of super-Earths - *A. Morbidelli*
10:00 - 10:15 Discovery of a planetary mass companion in the gap of the transition disk PDS 70
- *M. Keppler*
10:15 - 10:45 New Views of Debris Disks with ALMA - *D. Wilner*
10:45 - 11:15 Coffee break
11:15 - 11:30 The SPHERE View of 51 Eridani b - *M. Samland*
11:30 - 12:15 Discussion: from disks to planets - *C.P. Dullemond & C. Mordasini*
12:15 - 12:30 Conclusions - *T. Ray*

3 Participants

In total, 71 persons participated to the workshop.

The participants come from 11 countries (9.9% Italy, 9.8% UK, 9.8% Ireland, 22.5% USA, 8.5% France, 22.5% Germany, 5.6% Netherlands, 2.8% China, 1.4% Japan, 1.4% Switzerland, 1.4% Australia, 4.2% Chile).

40% of participants are female, 15% of participants are students and 23% are postdocs. The workshop could only be attended with an invitation from the Science Organizing Committee, and was attended by world known experts in the field, as well as very promising PhD students.

All students and postdocs were given the opportunity to present their work in talks (25 min for postdocs, 15 minutes for students). A few senior scientists gave complementary talks and the most senior scientists were in charge of leading long discussions and triggering new ideas in the community.

4 RadioNet financial contribution

The RadioNet contribution was used to support the general expenses of the main organizer (DIAS, Dublin), which include renting the conference room and renting the venue.

5 Publications

One publication was already submitted to ApJ after the workshop: Zhu et al. 2019, "One Solution to the Mass Budget Problem for Planet Formation: Optically Thick Disks with Dust Scattering". The paper features this acknowledgment : "Z. Z. thank the organizers of "Planet-Forming Disks, a workshop to honor Antonella Natta" to organize the great workshop, during which the $\tau=0.6$ problem was raised and the idea of this work came. The Planet Forming Disks workshop has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet], No 743029 [EASY], from INAF-Arcetri and iALMA contract No 6041, DIGDEEP contract No 706320. "