Report on the Joint ESO/MPE/MPA/LMU Workshop

From Circumstellar Disks to Planetary Systems

held at MPE, Garching, Germany, 3–6 November 2009

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A summary of the joint ESO/MPE/MPA/LMU workshop "From Circumstellar Disks to Planetary Systems" is presented. The meeting reviewed the status of our observational and theoretical understanding of protoplanetary disks, from the formation phase through their evolution to planet formation and debris disks.

The study of circumstellar disks and the formation of planetary systems has experienced enormous progress in recent years. Thanks to wide field imaging surveys with the Spitzer Space Telescope and ground-based near-infrared and submillimetre telescopes, unbiased samples of thousands of young stellar objects with disk luminosities down to 0.01 $L_{\odot}$ (the brown dwarf regime) have been identified in the nearest molecular clouds within ~ 1 kiloparsec. Photometry from optical to millimetre wavelengths provides spectral energy distributions whereas mid-infrared and submillimetre spectroscopy probes the gas and the solid state content. The ESO Very Large Telescope (VLT) and its interferometer (VLTI) in the optical/infrared, combined with millimetre and radio interferometers at longer wavelengths, are providing a wealth of high angular resolution observations to study disk structure and evolution. New and exciting developments range from evidence for grain growth and settling (the first steps in planet formation) as the disks evolve, to the development of gaps and holes in a new set of transitional disks, and to the direct detection of (proto-)planets around pre-main sequence stars. New facilities with enormous potential are lining up and are expected to start producing a wealth of new data: the Herschel Space Observatory and the Atacama Large Millimeter/submillimeter Array (ALMA) with the opening of Early Science in 2011. In the more distant future, protoplanetary disks are also a key theme for the James Webb Space Telescope (JWST) and the European Extremely Large Telescope (E-ELT).

The workshop was organised with the goals of reviewing the status of the field and discussing transformational programmes that will be made possible with the upcoming facilities, and especially by the combined use of present and future ESO facilities. To achieve these goals the workshop brought together the communities working with ground-based infrared large telescopes and interferometers, with space observatories and millimetre interferometers, as well as theorists and modellers. The second half of 2009 was chosen for the workshop on account of the perfect timing to: discuss observational programmes to be carried out with ALMA during Early Science; review the survey results from Spitzer and other large field facilities; present the new high angular and spectral resolution results that are coming from the ESO VLT/VLTI; view the first glimpses of the potential of Herschel. Indeed, this workshop distinguished itself from other recent meetings in the field by covering the full span of observational facilities (rather than just one specific instrument or wavelength) and by having a healthy mix of observations and models.

The workshop covered all the phases of the lifetime of disks: from disk formation, the role of disks in the formation and early evolution of stars, disk evolution including planet formation, debris disks and young planetary systems. The high level of attendance (the meeting was substantially oversubscribed) and lively discussions following the talks and at the poster sessions are a testimony to the maturity and the high rate of progress of the field (see Figure 1). The frequent reference in the talks to the prospects of Herschel, ALMA and in the more distant future, JWST and E-ELT observations, reaffirmed the key role of these facilities for the studies of disks and the formation of planetary systems. Most of the 53 talks presented are available on the workshop web pages[1]. Here we briefly summarise only a few of the many new results presented at the conference.

Selected results

The formation and properties of disks during the early stages of star formation, the so-called Class 0 phase, were discussed in the framework of recent Spitzer, Sub-Millimeter Array (SMA) and Institut de Radioastronomie Millimétrique (IRAM) Plateau de Bure interferometer (PdBI) results. The observations clearly show that compact flattened structures are formed in the very early stages of collapsing protostellar envelopes. The exact nature of these compact sources and their theoretical interpretation are still debated, as current observations cannot fully distinguish the "pseudodisk"

Figure 1. Workshop participants photographed outside the MPE seminar room.

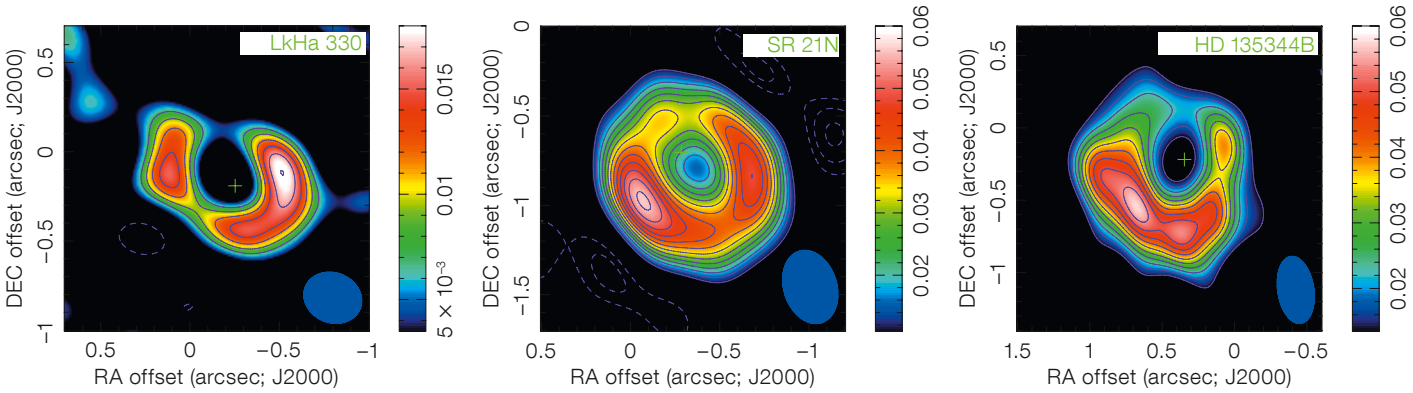

Figure 2. High angular resolution submillimetre continuum images of three transitional disks obtained at the SMA (Brown et al., 2009). The high angular resolution images reveal an inner region of the disk where the dust column density is much lower than in classical disks, possibly a result of disk evolution, which could be caused by photoevaporation, viscous evolution or clearing by young protoplanets.

predicted by models of collapsing magnetised clouds from the classical flat accretion disks. Key tests of the different models will soon be made possible by observing the kinematics of these compact structures using ALMA to detect and image rare molecular species.

The discussion of the statistics, diversity, chemical and physical properties of disks around pre-main sequence stars occupied a large fraction of the meeting. The power of Spitzer as a survey telescope was demonstrated by the results presented for several star-forming regions. It is now well established that disks with similar properties surround young stellar objects with masses ranging from brown dwarfs to a few solar masses, and even more massive stars are found to be associated with disks, albeit with different properties and lifetimes. Much work is being invested in the characterisation of the non-classical disks in an attempt to understand their nature and possible relationship with disk evolution. As an example, the possible role of photoevaporation or planet formation in shaping transitional disks was discussed (see Figure 2). Inner holes are detected in the dust distribution of several of these disks, but in many cases the interpretation is still ambiguous due to the limited resolution and signal-to-noise ratio of the observations, and the lack of high sensitivity and high angular resolution observations of the gaseous component of the disk. Winds and accretion represent an alternative indirect probe of the inner regions of disks and several new results in these areas were discussed at the meeting.

The evolution of the solid and gaseous components of the disks towards the formation of planets was the other major subject discussed by many theoretical and observational talks (see for example Figure 3). Millimetre-wave continuum observations of disks now show convincing evidence for the presence of large (mm–cm size) grains in the outer regions (radii ~ 100 AU) of protoplanetary disks. These findings challenge the theoretical predictions of dust fragmentation and migration and most likely require some form of trapping of large grains in small areas of the disk; a few possible mechanisms to achieve this trapping were presented. Resolving grain growth properties at millimetre wavelengths across disks is going to produce a major breakthrough in this area and should be within the capabilities of ALMA and the Expanded Very Large Array (EVLA).

The last part of the meeting was dedicated to young (exo-)planetary systems, debris disks and the dynamical interactions between planets and dust in young planetary systems. A handful of direct detections of planetary mass companions to nearby stars were presented (see example in Figure 4) and the interactions between these bodies and the debris disks in these systems were discussed in the framework of dynamical evolution models. The sophistication reached by the dynamical interaction models was discussed in several talks. Indeed, the variety of observed debris disk morphologies could be explained by these models using reasonable values for the mass and orbits of the planetary bodies. In addition, population synthesis models of planetary systems have reached a level of complexity that now allows for a detailed comparison of the properties of exoplanets with the observed distributions.

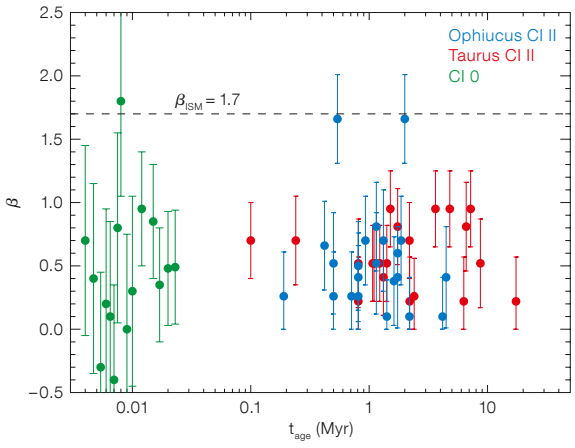

Figure 3. Dust opacity power law index as a function of age for a large sample of disks around isolated pre-main sequence stars in Taurus and Ophiuchus (red and blue points respectively) and for a small sample of young protostars in Perseus and Cepheus (data from Jørgensen et al., 2007; Kwon et al., 2009; and Ricci et al., 2010). The data show that the dust grains seems to have grown at least to millimetre sizes in all but two of the observed systems, suggesting that grain growth may be a fast process in the outer disk and that large grains survive much longer than predicted by models.

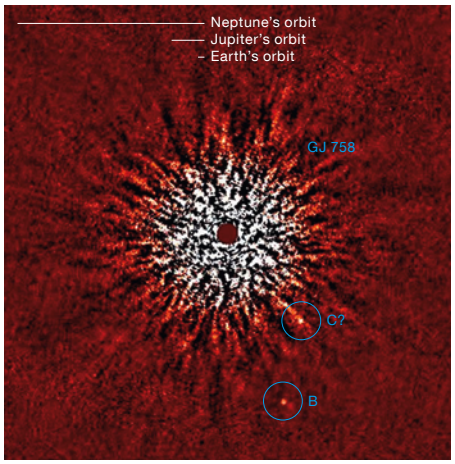

Figure 4 (above). Direct imaging detection of the planets around the G-type star GJ758 announced at the meeting (SUBARU/HiCIAO data, Thalmann et al., 2009).

The success and smooth organisation of this workshop would have not been possible without the help and support of Christina Stoffer and Jasmin Zanker-Smith, as well as the postdocs and students who served with enthusiasm and dedication on the Local Organising Committee (Joanna Brown, Greg Herczeg, Agata Karska, Pamela Klaassen, Luca Ricci, Paula Teixeira — see Figure 5). We also thank all our colleagues at the MPE for their patience and understanding during the invasion of their institute by over 200 conference participants.

References

Brown, J. M. et al. 2009, ApJ, 704, 496
Jørgensen, J. K. et al. 2007, ApJ, 656, 293
Kwon, W. et al. 2009, ApJ, 696, 841
Ricci, L. et al. 2010, A&A, in press, astro-ph: 0912.3356
Thalmann, C. et al. 2009, ApJ, 707, L123

Links

[1] Workshop web page: http://www.eso.org/sci/meetings/disks2009/index.html

Figure 5 (below). Local organisers, from left to right: Joanna Brown, Greg Herczeg, Pamela Klaassen and Paula Teixeira enjoying themselves at the workshop dinner and Luca Ricci and Agata Karska setting up presentations for the speakers during the workshop breaks.

Report on the CAUP and ESO Workshop

Towards other Earths: Perspectives and Limitations in the ELT Era

held in Porto, Portugal, 19–23 October 2009

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A short report on the workshop aimed at exploring the role of the Extremely Large Telescopes in finding and characterising Earth-like planets is presented.

The Centro de Astrofísica da Universidade do Porto hosted an ESO-sponsored conference, which had the main goal of understanding how Extremely Large telescopes (ELTs) will help in finding and characterising other Earth-like planets, as well the challenges that we have to overcome to achieve this goal.

In order to enable the discovery and characterisation of other Earths, a new generation of instruments and telescopes is now being conceived and built by different teams around the world. With the large diameter of their primary mirrors, the new generation of ELTs will play a crucial role in this research and the detection of Earth-mass planets is expected to be within reach.

In parallel, a new generation of instruments for current 8 to 10-metre-class facilities is being planned. The new cut-