Highlights of Astronomy, Volume 15
XXVIIth IAU General Assembly, August 2009
Ian F. Corbett, ed.

doi:10.1017/S1743921310009026

Accretion Disks around low-mass Stars unveiled by the new Generation of cm to submm Arrays

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Abstract. In the context of accretion disks, I briefly discuss the impact of three major forthcoming radio facilities: e-VLA, ALMA and SKA. These arrays are complementary by their frequency range and angular resolution. Around nearby low-mass stars, they will likely provide the first insights in the inner gas and dust disks (radius < 10-30 AU) in the area where planet formation should occur but would also allow the first investigations of the star, jet and disk connections.

Keywords. accretion disks - stars: formation - planetary systems: protoplanetary disks

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Investigating the physics and chemistry of the dust and gas orbiting around low-mass stars is a key issue in order to understand how young planetary systems form and evolve from the residual of the molecular dense core which has formed the star: the so-called proto-planetary disk. Young disks are mostly composed of H_2 which is difficult to detect and most observations are based on other tracers.

The cm to submm wavelength domain is well suited for this purpose because 1) the dust has a moderate opacity, allowing to trace the disk mass content and 2) there are many rotational lines of simple molecules such as CO, CN, HCN, H_2CO, etc... which can probe the gas content. Other major issues, linked to the processes leading to star and planet formation are the understanding of the jet physics and its connections to both the central star and the disk. In this field, the cm wavelengths are well suited to trace free-free emission from jets or the non-thermal processes emanating from young magnetically active stars and interacting with the inner disk. Finally, due to the small angular size of disks, only large interferometers have the angular resolution needed to resolve out the inner part of disk where planets should form (10 AU $\simeq$ 0.07" at 150 pc). In the radio domain, thanks to their sensitivity and imaging capabilities, three arrays will have a major impact in this astrophysical field: e-VLA, ALMA and SKA.

e-VLA is the "Expanded Very Large Array" located in Socorro, New Mexico, USA. The VLA has been gradually improved by adding new receivers and a new correlator. In particular, the array will be operated from 1 to 50 GHz. The full upgrade will be completed in 2012. More information can be found on the NRAO site at: http://www.aoc.nrao.edu/evla/.

ALMA, the "Atacama Large Millimeter Array", is currently in construction in the Atacama desert in Chile. This will be an array of 66 antennas (54 12-m dishes for the main array and 12 7-m dishes for the compact array ACA) working between 30 GHz (this bandwidth is not yet decided) and 900 GHz on baselines as long as 15 km. The array will gradually enter in regular operation starting in 2011. More information can be found at http://almaobservatory.org.

SKA is the "Square Kilometer Array", a gigantic network of radio antennas working from 70 MHz up to 30 GHz (but the high frequency bandwidth, above 10 GHz, is still an option). Several sites are under investigation. The array is expected to be in operation around 2020. More information can be found at http://www.skatelescope.org/

In the course of understanding how stars and planets form, there are several domains which will benefit from the high sensitivity, high angular resolution images provided by these new interferometers. In this context, here is a non exhaustive list where these new instruments would provide invaluable information:

(*a*) Nowadays, star-disk interactions linked to stellar magnetic loops (Massi *et al.* (2006)) are mostly observed in close (spectroscopic) binary systems which present variable emissions from a few cm up to the mm range Salter *et al.* (2008). Thanks to their sensitivity and angular resolution, e-VLA and SKA would likely change our views in this domain by better constraining the magnetic activity of PMS TTauri stars.

(*b*) Ionized jets will be soon mapped by the e-VLA and more accurately by SKA ten year later (Rodriguez *et al.* (1994)). These high quality images would allow to study not only the jet in itself but would partially unveil its connections with the disk and the star.

(*c*) Dust disks, including planet forming regions (radius < 50 AU), will be imaged with ALMA, e-VLA and SKA (if the band at 20-30 GHz is implemented). This will permit to trace gaps potentially due to planet-disk interactions (Wolf and D'Angelo (2005)) but also provide better constrains on grain size distribution, dust mass estimate and its evolution with disk age. Observations around 7mm are of prime importance not only to characterize grain growth but also to disentangle with a partial contamination of the spectral energy distribution (SED) by an ionized jet (Rodman *et al.* (2006)).

(*d*) Mapping of gas disks will mostly remain the domain of ALMA (Dutrey *et al.* (2007)) through the observations of many molecular lines from 3 up to 0.3mm. However, only e-VLA and SKA would detect NH_3 around 25 GHz, a key molecule to understand the nitrogen chemistry and which is not yet observed in gas disks. Moreover, SKA and maybe e-VLA should be able to detect the HI line at 21 cm, tracing the neutral gas at the disk surface (Kamp *et al.* (2007)), a particularly interesting information for the disk dissipation.

(*e*) Last but not least, polarimetric measurements provided from both dust (Girart *et al.* (2008)) and line (through CN or C_2H Zeeman splitting or CO with the Goldreich-Kylafis effect, for example) emissions should provide estimates of the magnetic field in the inner disk at scale around 10 AU. For this purpose, sensitivity is an issue even for ALMA, particularly for line observations.

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