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The origin of the obliquity in planetary systems studied with infrared interferometry

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Observations of the Rossiter-McLaughlin effect have revealed that the orbits of many exoplanets are misaligned with respect to the stellar rotation axis. Various scenarios have been proposed that associate the orbit obliquity either with multi-body interactions or dynamical processes in the disc during the planet formation process. In this talk, I will present how infrared interferometry allows us to study the origin of the planet obliquity:

In the first part of the talk I will present observations that reveal the recently-posted disc tearing effect, where the gravitational torque of companions on misaligned orbits can tear the disc apart into distinct rings that precess independently around the central objects. We imaged the triple system GW Orionis using VLTI, CHARA, ALMA, SPHERE, and GPI and discover three rings in thermal light and an asymmetric structure with radial shadows in scattered light. The inner-most ring is eccentric (e=0.3; 43 au radius) and strongly misaligned both with respect to the orbital planes and with respect to the outer disc. Modelling the scattered light signatures and the shape of the shadows cast by the misaligned ring allows us derive the shape and 3-dimensional orientation of the disc surface, revealing that the disc is strongly warped and breaks at a radius of about 50 au. Based on the measured triple star orbits and disc properties, we conducted smoothed particle hydrodynamic simulations which show that the system is susceptible to the disc tearing effect. The ring offers suitable conditions for planet formation, providing a mechanism for forming wide-separation planets on highly oblique orbits. Our results imply that there may exist a significant, yet undiscovered population of long-period planets on highly oblique orbits that has formed around misaligned multiple systems.

In the second part I will show how infrared interferometry can be used to search for this predicted population of wide-separation planets on oblique orbits, probing a highly complementary regime to the parameter space accessible with the Rossiter-McLaughlin effect. I will present the first study where the spin-orbit alignment has been measured for a directly-imaged exoplanet, namely on Beta Pictoris b. We used VLTI/GRAVITY spectro-interferometry with an astrometric accuracy of 1 microarcsecond to measure the photocenter displacement associated with the stellar rotation. Taking inclination constraints from astroseismology into account, we constrain the 3-dimensional orientation of the stellar spin axis and find that Beta Pic b orbits its host star on a prograde orbit with a small obliquity angle.

I will conclude by offering a near-term perspective on how infrared interferometry with the proposed BIFROST beam-combination instrument could advance our understanding of the planet formation process and of the early dynamical evolution of exoplanetary systems.