Characterization of debris discs in direct imaging with VLT/NaCo and VLT/SPHERE

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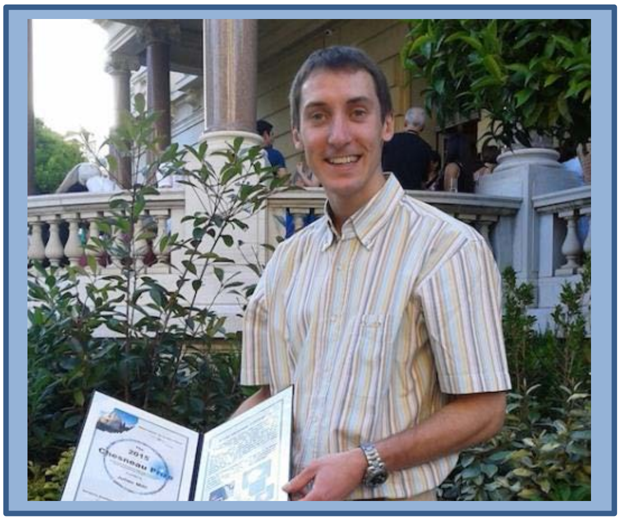
Co-financeurs : ESO (66%)

École doctorale : Physique

Début / Soutenance : 01/10/2011 - 23/09/2014

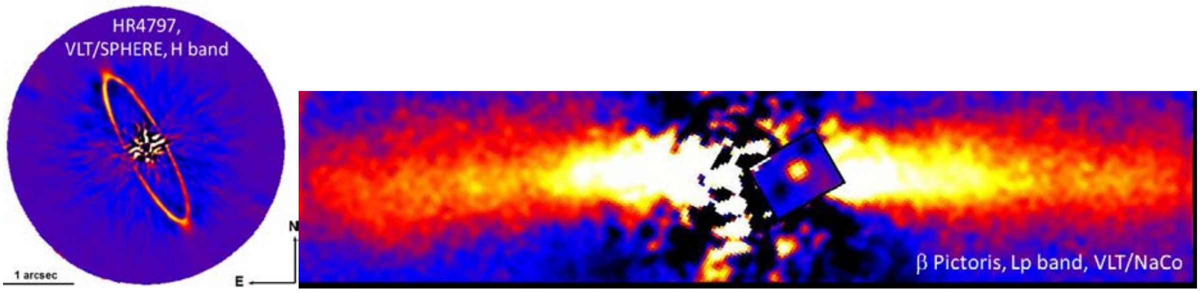
Formation : Master d'Astrophysique de l'Université Paris 7

Poste actuel : Adaptive Optics Scientist à l'ESO



Résultats majeurs et illustrations

- Debris discs are faint and their detection and characterization in direct imaging require high-contrast capabilities and dedicated observing strategies.
- Developments of advanced data reduction algorithm for discs and deep understanding of the instrument behaviour and stability.
- Prediction of performances of SPHERE with laboratory and on-sky measurements
- Measurements and interpretation of the morphology and dust grain properties of two prominent debris disks: β Pictoris and HR4796
- Distinctions: Prix Olivier Chesneau 2015 (selecting the best PhD in high angular resolution for astrophysics worldwide)



Debris disk images obtained in near infrared light scattered on small dust grains, with SPHERE instrument, at unprecedented accuracy and short separation from the star. Left: dust ring around HR4796; right: edge-on disk around β Pictoris, together with detected giant planet.

Résumé de la thèse

Over the last two and a half decades, the discovery of more than 1800 exoplanets has been a major breakthrough in our understanding of planetary systems. To shed light on the formation and evolution processes of such systems, I have chosen an observational approach based on the study of debris discs. These circumstellar discs are composed of dust particles constantly generated by collisions of small rocky bodies called planetesimals, orbiting a main-sequence star. The stellar light they scatter can be studied from the Earth and reveal a wealth of information on the architecture of the system. These observations are challenging because of the high contrast and the small angular separation between the disc and the star. The recent developments of new high-contrast instruments with extreme adaptive optic systems are therefore bringing new expectations for the study of these systems and set the framework of this PhD thesis. My work aims at characterising debris discs thanks to two instruments installed on the Very Large Telescope: NaCo and SPHERE (Spectro Polarimetric High contrast Exoplanet REsearch). NaCo has been in operation for more than a decade and has undergone many improvements. SPHERE has been designed and assembled in the same period, was intensively tested in laboratory in 2013, and is currently being commissioned on the telescope. The innovative approach of this PhD work is to combine the study of debris discs with strong instrumental expertise to get the best science results from the observations. The first part of the study aims at developing innovative data reduction techniques adapted to the observations of discs in scattered light and to the behaviour of the instrument. I quantify in particular the performances, advantages, and biases of the angular, polarimetric and reference-star differential imaging technique. In a next step, I apply those techniques to characterise two prototypes of debris discs, around the stars beta Pictoris and HR 4796A. A detailed analysis of the morphology is carried out, which reveals new asymmetries interpreted in terms of gravitational perturbers or of dust scattering properties. Lastly, I detail the expected and measured performances of SPHERE, from simulations, laboratory and on-sky measurements. A comparison with NaCo reveals the assets of SPHERE and I conclude with the scientific questions SPHERE will be able to answer with new debris disc observations.

Collaborations

European Southern Observatory (ESO), number of European Institutes (Liège, Paris, Marseille, Heidelberg, Zurich,…), Caltech, Baltimore (STSci)

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