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Directly Imaging Exoplanets and Disks in the nearest young OB Association

Abstract	The project aims to directly image exoplanets and their disks in the nearest OB association, called Sco-Cen. The stars are very young (16 Million years old) analogues to our Sun. The student will search for exoplanet companions and disks around these stars at unprecedented sensitivities using the exoplanet imaging instruments SPHERE (on VLT) and Clio (on Magellan). The results will increase our understanding of the planet formation process in the Solar system.
Background	The direct imaging of exoplanets complements the exoplanet discoveries by radial velocity and transit, providing additional insight into the architecture of exoplanet systems at Solar system scales. One significant challenge for interpreting the nature of directly imaged faint companions is the uncertainty in their age. Searching in young stellar OB associations of known ages breaks this degeneracy between observed flux and their mass. The Sco-Cen OB association has an ideal age (17 Million years) to look for exoplanets still bright from their heat of formation in the infrared, and to look for circumstellar disks in polarized light at the optical. Their mechanism of formation can be deduced from their metallicity and location relative to their host star and any detected circumstellar disk.
Aims	Over 200 new solar-type members of the association have been identified by our group. These stars have never been imaged at high contrast before, so our aim is to directly image these new stellar candidates, detect new exoplanets and circumstellar disks, and interpret these results.
Study design and methods	We are obtaining the first observations from SPHERE in Spring 2015. A graduate student will identify new planets and disks that can be followed up with photometric monitoring for weather on these exoplanets, and at longer wavelengths with ALMA sub-mm observations.
Clinical and/or scientific relevance	Detection of new extrasolar planets will enable studies of their formation mechanisms and composition, placing them in the context of star and disk formation and planetary system architectures.
Requirements of candidate	Masters degree in Physics or Astronomy equivalent. IELTS Grade of 7.0 or higher, or TOEFL iBT 100 or TOEFL PBT 600.
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The Galaxy according to Gaia

Background	The Gaia satellite was launched successfully in December 2013 and in the summer of 2016 the first data is released, these including parallaxes, proper motions, and astrophysical parameters of one billion stars. More data is expected by mid 2017. At the same time the quality of large scale numerical simulations — in terms of accuracy and resolution in mass and time — of our Galaxy is rapidly developing. With modern GPU-equipped supercomputers like titan, we can now perform simulations with a resolution comparable to the observations of the Gaia mission.
Aims	We propose to combine our expertise in the areas of the Gaia mission and its data, large-scale simulations of the Milky Way, and theoretical understanding of the relevant physics to address the following questions about the fine structure of the Milky Way. I) to what degree is the stellar population around the Sun mixed: where are the siblings of the Sun and planetary systems similar to our own? II) What are the properties and history of the bar and spiral arms pattern? And III) what causes the vertical heating of the Galactic disk: constraining internal vs. external mechanisms, using the velocity ellipsoid across the disk.
Study design and methods	State of the art computer simulations, using the AMUSE framework that has been developed here in Leiden Observatory, will be used to simulate the Galaxy and help interpret observations from GAIA. The simulations will be run on supercomputers available to the group in Leiden. Clinical and/or scientific relevance: The Gaia mission data will revolutionize our understanding of the Milky Way. Exploiting this data requires simulations and theory. We have written the fastest N-body methods running on the planet's largest computers with which we can simulate the Milky Way Galaxy on a star-by-star basis. The methods we expect to develop during this project can be ported directly to other research fields, including molecular dynamics and other particle based research projects.
Requirements of candidate	Masters degree in Physics or Astronomy equivalent. IELTS Grade of 7.0 or higher, or TOEFL iBT 100 or TOEFL PBT 600.
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LOFAR and the formation and evolution of galaxies, clusters of galaxies and massive black holes

Abstract	LOFAR, the Low Frequency Radio Array, is a pan-European radio telescope that is opening up the ultra low frequency (10 - 240 MHz) sky for astronomical observations. LOFAR is currently delivering the most sensitive maps of the radio sky from scales of arc seconds to over thousands of square degrees. These deep images will be used to carry out a coherent study of clusters of galaxies over the entire history of the universe up to the formation of the first proto-clusters. LOFAR's unprecedented sensitivity at ultra-low frequencies and large observing bandwidth are ideally suited to observe radio sources in nearby clusters. This will constrain (i) the geometry of merger events, (ii) the physics of cluster wide shocks and particle acceleration, (iii) the origin of cosmic magnetic fields, and (iv) the energy content of the thermal and non-thermal cluster gas. The large fields of view of both LOFAR and APERTIF will enable the detection of radio emission from millions of star-forming galaxies up to z=2-3, at the epoch at which the bulk of galaxy formation is believed to have occurred. In combination with infrared surveys, the first significant sample of the ancestors of massive clusters of galaxies, proto-clusters, will be obtained. This will enable the first complete study of the overall properties of proto-clusters and their galaxy contents. With LOFAR's ability to pinpoint radio sources with extremely steep radio spectra, we will detect radio galaxies at unprecedented distances. LOFAR radio spectroscopy targeting neutral hydrogen 21 cm absorption would, for the first time, determine physical characteristics of neutral gas in such objects. Subsequent observations with large optical and IR telescopes will constrain models of how massive galaxies and associated massive black holes form within the first collapsing over-densities in the early Universe. Within this project, students will be involved with making very deep maps of the low frequency sky and address several of the science questions related to the formation and evolution of structures in the Universe.
Requirements of candidate	Masters degree in Physics or Astronomy equivalent. IELTS Grade of 7.0 or higher, or TOEFL iBT 100 or TOEFL PBT 600.
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