

Kepler Center for Astro and Particle Physics

In the very last years the intersections of particle physics, astrophysics, and cosmology have grown wider and complex, establishing the field of Astro- and Particle-Physics as a rapidly growing young interdisciplinary field. We intend to advance this new interdisciplinary field in an unprecedented way establishing the **Kepler Center for Astro and Particle Physics** at the Eberhard Karls University Tübingen. With the creation of the Kepler Center we have the opportunity to combine and coordinate the unique collection of expertise present in the University of Tübingen in a network effort that will closely link astronomy and particle physics building an integrated environment for research and education.

The physics goals of the Center are:

- Using the Universe as a laboratory for elementary particles and for matter and energy under extreme conditions
- Studying the Universe through multi-messenger observations
- Studying the properties of elementary particles and their influence on the evolution and the structure of the Universe
- Constructing theoretical models to understand the processes within our Universe

Such an interlinked research program will hopefully provide answers to some key questions:

What can we learn of the extreme processes in our Universe through the observation of high energy photons, neutrinos, gravitational waves? Which is the physics of matter under extreme conditions like extreme density, gravity, magnetic field and temperature? Will we have access, through neutrinos and gravitational waves to the darkest, coldest and densest areas of the present, past and very early universe? And how planets formed and evolved into the observed systems?

Can we learn more about elementary particles through cosmological observations like large structure observations? Do we understand yet completely the structure of matter or there is physics beyond the standard model of particle physics? What is made of the main invisible component of the Universe that reveals by gravitational forces, the 'Dark Matter', which cannot be explained by the presently known set of elementary particles? Even the answer to such a basic question of how matter came into the Universe is not known yet. It is probably related to very subtle properties of the neutrinos or other not yet discovered particles.

Providing such answers and detecting such particles would be a breakthrough for astrophysics as well as for particle physics.

The groups presently involved in the Kepler Center are:

H.Clement, P.Grabmayr, J.Jochum, W.Kley, K.Kokkotas, A.Santangelo, and K.Werner

The activities of the center will include:

- observational astronomy from optical up to TeV photons (*galactic and extragalactic astrophysics*)
- Experimental High Energy Astrophysics (*WSO, XMM, INTEGRAL, eRosita, SIMBOLX, HESS I & II*)
- high energy cosmic rays (*JEM-EUSO, SUPER-EUSO*)
- theoretical and computational astrophysics (*Planet formation, Physics of Accretion disks*)
- general relativity and gravitational waves (*astrophysical and theoretical studies*)

- experimental astroparticle physics (*dark matter search CRESST and EURECA*)
- experimental neutrino physics (*ν -less double β -decay GERDA, ν -oscillations Double Chooz*)
- experimental particle physics (*nucleon-nucleon interaction COSY*)
- theoretical particle physics

Such a combination of astronomy, astrophysics, general relativity, particle physics research together with a very rich experimental program cannot be found elsewhere in Germany.

The groups within the planned Kepler Center have been very successful during the recent years **in acquiring funds**, which amount presently to 3 MEuro per year from a large diversity of sources:

Deutsche Forschungsgemeinschaft:

- Transregio 7 SFB (DFG) on ‘Gravitational Waves’
- Transregio 27 SFB (DFG) on ‘Neutrinos and Beyond’
- European Graduate School ‘Hadrons, Nuclei and Stars’ (DFG) together with Basel and Graz
- Forschergruppe 759 “Formation of Planets”
- Several Minor Grants

BMBF:

- Verbundforschung ‘Astronomie und Astroteilchenphysik’
- Verbundforschung ‘Hadronen und Kerne’
- COSY-FFE (Forschungszentrum Jülich)

EU- FP6:

- ‘ILIAS’ (Integrated Large Infrastructure Initiative for Astroparticle Science)
- ‘I3HP’ (Integrated Infrastructure Initiative for Hadron Physics)
- Network on “Planet Formation”

DLR

- Verbundforschung “Astronomie und Astrophysik”
- Experimental Projects: INTEGRAL & XMM Newton, eROSITA, Simbol-X , WSO

The Kepler Center shall in future bundle the funding activities to present the activities in Astro and Particle Physics at the University Tübingen in a coherent way towards the scientific community: this will allow the single Institutes to acquire critical mass in international projects.

Teaching is also at the base of the Kepler Center mission. As one of the most important first steps, a proposal for a Graduate School will be prepared. The Kepler Center will manage the existing ‘Vertiefungsfach – Astronomie & Astrophysik’ and will newly develop an interdisciplinary ‘Vertiefungsfach – Astroteilchenphysik’ for the Master program, teaching the interplay between cosmology and particle physics.

The Kepler Center offers a very active international exchange program. The center is involved into a number of larger scale projects carried out in international co-operations. There are regular visits among the partners where the students at the Kepler Center will have plenty of chances for international contact. On return, several times per year we have long term visits from scientists from abroad at Tübingen, where the guests co-operate with our students on the common projects.

In conclusion, the close connection in Tübingen between experiments, theory and general relativity appears as an unique opportunity, not present elsewhere in Germany, to be a very

attractive place for the interdisciplinary cooperation between particle physics and astrophysics.