Division of particle physics and astrophysics PAP 2017-2020

The research fields of PAP form a continuum from experimental and theoretical particle physics through theoretical and observational cosmology, astrophysics, and solar system physics to space physics involving solar activity and its consequences in the solar system.

The PAP research belongs to the University of Helsinki strategic research area *Matter and Materials*. In the Division the fundamental constituents of matter, as well as matter in extreme conditions is studied. Theoretical particle physics belongs also largely to the University spearhead *Mathematics*. High-luminosity operation of the Large Hadron Collider (LHC), which is the main particle physics infrastructure we use, has been identified as the highest priority in the latest European Particle Physics Strategy (see http://cds.cern.ch/record/1551933/files/Strategy_Report_LR.pdf). Research at CERN is included in the Finnish Research Infrastructure Roadmap.

Within the existing research programme we will exploit the synergy between the groups in particle physics and cosmology. We also aim to strengthen the links between observational cosmology and astrophysics.

Experimental particle physics

The LHC Run 2 continues until 2019. Our first priority in experimental particle physics is the exploitation of the LHC, where the Run 2 is providing collisions at record energy and record intensity, with potential for new discoveries. Parallel to that we are participating in preparation for further experiment upgrades, with the projected Run 3 starting in 2021. We take part in the CMS and TOTEM –experiments, as well as forward physics at ALICE, and in the Moedal-experiment. We are involved in the preparations of the Technical Implementation Plan for the future Compact Linear Collider CLIC.

Particle theory

We work at the internationally highest level in beyond the Standard Model physics and particle cosmology, which are among the main research directions in theoretical particle physics. The research topics range from the largest scales to the smallest, including inflation, gravitational waves, dark matter, phase transitions, Higgs physics, flavour physics, CP violation.

Cosmology

Using ground base ESO surveys, we participate in characterizing the large-scale structure of the Universe. We participate in the cosmology missions of the European Space Agency, in particular Planck and Euclid, where we are the leading institute in Finland. Planck made observations in 2009-2013, but the data analysis continues. We are preparing for Euclid mission, which will mass-calibrate the Universe. Euclid will be launched in 2020, and we provide one of the nine national Euclid Science

Data Centers, SDC-FI.

Astrophysics

We aim to understand the role of black holes in the evolution of galaxies and the role of environment. Similarly our goal is to understand the physical and chemical composition of interstellar matter, the formation of dense interstellar molecular clouds, and the final evolution leading to cloud collapse and the formation of new stars in the Milky Way.

In theoretical astrophysics, our main priorities will include 1) accurately modelling the dynamics of supermassive black holes in both merging and cosmologically evolving massive galaxies and to understand the influence of the black holes on galactic evolution; 2) developing the most accurate simulated model of the local Universe to date by running a very high-resolution full physics simulation of the Local Galaxy group and its immediate neighbourhood; and 3) simulating the formation of massive elliptical galaxies using both merger and cosmological simulations in order to understand the assembly of their stellar components both as a function of time and environment.

Space physics

Space research group studies the solar-terrestrial physics and space weather. The emphasis of our research is on understanding the formation of solar eruptions and their evolution in the heliosphere and consequences in the near-Earth space and at other planets of our solar system.

Planetary Research

Planetary research focuses in on deriving the physical properties and dynamical evolution of small Solar System bodies, such as near-Earth objects, asteroids and comets at large, and planetary satellites, as well as on the physical and chemical properties of meteorites. Theoretical and experimental studies are carried out on the interaction of electromagnetic radiation (scattering, absorption, and emission) with cosmic dust in planetary regoliths and elsewhere, from Solar System objects through the interplanetary medium to the interstellar medium and extrasolar planetary systems.