Master projects

Galactic Magnetic field

The Galactic magnetic field (GMF) consists of a regular and a turbulent component. Since charged particles diffuse in this field, the GMF influences the interpretation of many phenomena in the Milky Way, reaching from the astrophysics of high-energy cosmic rays, the interpretation of anisotropies in the cosmic microwave background to the detection of dark matter. Aim of this project is to improve the description of the regular component of the GMF, modeling its spiral structure analogous to the one of matter. As constraint, measurements of Faraday rotation using pulsars and synchrotron maps have to be taken into account.
The project is well-suited for a student interested in astrophysics and the numerical modeling of data.

Electroweak Bremsstrahlung and Dark Matter

Both calculations of the dark matter (DM) abundance and interpretations of indirect searches for DM require theoretical predictions for the annihilation or decay rates of DM into stable particles of the standard model. It is known that electroweak bremsstrahlung of Z and W-bosons has a significant influence on the branching ratio and the spectral shape of the final state particles, if the DM particle is heavy. Aim of this project is to study the influence of electroweak bremsstrahlung on the total annihilation cross section of DM: In this case, large logarithms $\ln^2(m_X^2/m_W^2)$ may or may not cancel depending on the model. Possible models to consider are toy models (like "wino" DM) and their mapping on the minimal supersymmetric standard model.
The project is suited for a student with some basic knowledge of QFT (e.g. FY3464), a strong interest to learn more and good analytical skills.

Antideuterons as Signature for Dark Matter Searches

Dark matter (DM) annihilations or decays produce the same amount of matter and antimatter, while "normal stuff" consists only of matter. Antimatter can be used therefore as a tool to search for DM in our galaxy. In particular, antideuterons which can be produced by the coalescence of an antiproton and antineutron offer an opportunity to search for DM at low energies. Aim of this project is to study and to develop further models that are used to describe (anti-) deuteron production, and to calculate the resulting antideuteron fluxes.
The project requires the use of state-of-the-art Monte Carlo simulation to handle the production of nucleons which then bind to form antideuterons. Thus interest both in computing and particle physics is required.

Plasma instabilities

A system of charged particles described by a distribution function $f(x, p)$ that deviates too strongly from an equilibrium distribution is unstable and develops instabilities. An example for an anisotropic distribution function is the beam of electron-positron pairs produced by the TeV photons emitted by a blazar, a special type of active galactic nuclei. Aim of this project is to find the time-scale of these instabilities and to determine if they are relevant compared to other physical processes for the conditions in intergalactic space. Dependent on the interest of the student, the problem could be tackled either from the classical plasma physics or from the quantum field theoretical side.