

# ANR-funded PhD studentship in the HESS experiment

**Subject: Search for new physics in the extragalactic sky with HESS**

*Research unit:* CEA, Irfu, Particle Physics Department

*Supervisor:* Pierre Brun

Ground-based gamma-ray astronomy is now in a mature phase, thanks to the success of Cherenkov telescope arrays HESS, MAGIC and VERITAS. The high sensitivity of these instruments allow using observations of the very high-energy universe to search for new physics. This can be new effects, like Lorentz invariance violations, or new particles such as those predicted in beyond standard model theories. Among them can appear particle dark matter candidates such as the neutralino or Kaluza-Klein particles, or axion-like particles, as predicted by the Peccei-Quinn mechanism or by some realizations of string theory. The HESS team in Saclay has a long experience in analyzing HESS data to conduct such studies. Numerous publications were issued from the group, about non-baryonic dark matter, primordial black holes, axions and gravitational lens effects. In all cases, the associated phenomenology and the related conventional astrophysical studies are worked out and can be the object of specific publications.

The proposed PhD subject is within that framework. The idea is to use photons originating from the particle acceleration processes in astrophysical environments. One particularly interesting idea is to focus on extragalactic observations and use photons witnessing particle acceleration in active galactic nuclei (AGN). In principle the observation of those allow studying at least five fundamental subjects: the extragalactic background light of the Universe, the search for axion-like particles, the large-scale magnetic fields in the Universe, the search for Lorentz invariance breaking and the study of high-energy photon gravitational lensing. The successful candidate will be member of the HESS collaboration and will participate in the data taking in Namibia and in the development of new data analysis tools. This is essential as HESS entered a new phase last year with a fifth telescope in operation, which allows lowering the energy threshold for observations --a crucial point to extragalactic observations. The first topics to be studied are the observation of AGNs and the measurement of the extragalactic background light. They correspond to the building blocks of subsequent analyses. Then the investigations will go on with the search for axion-like particles and the study of large-scale intergalactic magnetic fields.

The work will mainly consist of data analysis, as well as phenomenology studies. Concerning phenomenology studies, it is envisaged to take advantage from on-going collaborations with theorists from IPhT-Saclay. HESS data will be utilized, together with publicly available data from other observatories (Fermi, X-ray or radio telescopes) depending on the needs of the physics analyses. Eventually the results will be extrapolated for prospects to the next generation ground-based Cherenkov observatory, CTA. A technical activity is also foreseen for CTA (electronics or development of new generation mirrors). This PhD studentship is funded for 3 years in the framework of the ANR project CosmoTeV, which purpose is the use of extragalactic TeV observations for cosmology and fundamental physics. The PhD work should be preceded by a research internships that could start as soon as the candidate is selected.

Candidates should have a master degree in high-energy physics or astrophysics. Application is done via email, and should include a CV, copies of project theses, transcripts of academic records, contact details for academic referees. Deadline for application is March 31st 2014.

*Contact:* Pierre Brun  
*pierre.brun@cea.fr*  
*+33 1.69.08.42.64*

Example of references relevant to the current proposition

- HESS experiment: <http://www.mpi-hd.mpg.de/HESS>, description of the instruments, and organization of the collaboration

- P. Brax, P. Brun, D. Wouters, "*Gamma-ray and X-ray astrophysical tests of modified gravity models*", in prep.

- D. Wouters, P. Brun, "*Anisotropy test of the axion-like particle Universe opacity effect: a case for the Cherenkov Telescope Array*", JCAP 01 (2014) 016, arXiv:1309.6752

- HESS Collaboration, "*Constraints on axion-like particles with H.E.S.S. from the irregularity of PKS 2155-304 energy spectrum*", Phys. Rev. D 88 (2013) 102003, arXiv:1311.3148

- A. Barnacka, R. Moderski, B. Behera, P. Brun, S. Wagner, "*PKS 1510-089 - a rare example of a flat spectrum radio quasar with very high energy emission*", Astron. & Astrophys., in press, 2013, arXiv:1307.1779