Impuls- und Vernetzungsfonds Helmholtz Gemeinschaft

Project VH–NG–006: 2006 Activity Report

May 3, 2007

Group Members (2006)

- Group Leader: Koichi Hamaguchi (DESY) until April 2006
  Laura Covi (DESY) from Mai 2006
  (K.Hamaguchi moved to Tokyo University.)
- Postdoctoral Fellows: Jörn Kersten (DESY) until September 2006
  Florian Bauer (DESY) from October 2006
  Gianfranco Bertone (INFN, Padova) until April 2007
- Graduate Student: Jan Hamann (DESY) until April 2007
  — L.Covi supervised the dissertation of J. Hamann.

The members of the group VH–NG–006 "Particle Physics and Cosmology" have been working on several topics in the field of Particle Physics and Cosmology. Here we report about the activities and publication list in 2006 and early 2007.

Indirect Dark Matter detection (G. Bertone, J. Kersten)

Current strategies of indirect Dark Matter (DM) detection are looking at the centre of galaxies, of the sun or the earth, where a large number of weakly interacting DM could have accumulated. We have proposed a new strategy based on the detection of Dark Matter annihilations in 'mini-spikes' around Intermediate Mass Black Holes. The fluxes and the type of particle produced, in this case, depend on the annihilation cross-section of the Dark Matter particles. During this year we have explored the prospects of detections of such signal in gamma rays [1, 2] and in proton-antiprotons [3]. We have considered as well the effect of astrophysical processes on the inner galactic density, which could modify the spike prediction of usual DM profiles [5, 4] especially in the case of the formation of a black hole in the galactic centre. In all cases we find promising and characteristic signatures, that could allow to identify a weakly interacting DM candidate.

Dark Matter could be even more than weakly interacting, as in the case of the gravitino, the superpartner of the graviton. In that case, though, some indirect signal could still be visible, if the next-to lightest particle (NLSP) is a stau and it is produced by cosmic neutrino interactions in the earth. We have studied the signal of these unstable stau at neutrino telescopes in [6] and we found that they could give up to 50 events per year in the ICEcube detector if the stau mass and neutrino flux are near the experimental bounds.

Gravitino Dark Matter (L. Covi, K. Hamaguchi, J. Kersten)

The gravitino is a natural candidate for DM if it is the lightest supersymmetric particle (LSP), since it is neutral and stable or very very long-lived. We have continued our studies of the gaugino mediated SUSY breaking scenario, where the gravitino can be naturally the LSP and the possible NLSPs are the lighter stau, the left-handed tau sneutrino or the neutralino. We have explored the cosmological bounds on such scenario in [7] and found that viable regions of the parameter space survive practically only in the case of the sneutrino NLSP. In such case one would have also particular signals at colliders due to the very close spacing of the supersymmetric spectrum, like the chain decay of the lightest neutralino $\chi_1^0 \to \tilde{\tau}\tau \to \tau\tilde{\nu}_\tau \ell \nu_\ell$ [8]. The stau NLSP region, which offers the spectacular signal of a quasi stable charged particle at

colliders, is allowed only if one disregards the effect of bound states on Big Bang Nucleosynthesis (BBN). Nevertheless, it is possible to avoid such constraint either if the NLSP lifetime is shorter than 10^3 s, as can naturally happen if R-parity is slightly broken like in the model described in [9], or if there is entropy release after NLSP freeze-out and before BBN [10]. Note that a phase of entropy release could also be needed to dilute the gravitino overproduction by non thermal processes like inflaton decay, as studied in [11, 12].

Inflation and CMB (L. Covi, J. Hamann)

We have continued the studies of a class of inflationary models characterized by a step-like behaviour of the inflaton mass. Such models violate briefly the slow roll conditions and present distinctive features in the power spectrum of the curvature perturbations, which appear as a superimposed oscillation. We have used a Markov chain Monte Carlo algorithm to analyse CMB data from various experiments, as well as large scale structure data to find traces of such a feature in the potential. We found that there is no conclusive evidence for the presence of a step in the inflaton potential and derived bounds on the step parameters, both for the simplest model and for a more general case [13, 14]. Another important issue in such Monte Carlo parameter scans, is the dependence of the parameter intervals from the priors and the model assumed; we have performed a thorough study of possible degeneracies in [15].

Conference contributions (All)

All the members of the group have been very active presenting their results at international conferences and local meetings. Some of the presentations to be published are given in [16, 17, 18, 19].

2007 Plan (F. Bauer, L. Covi, NN, NN)

Unfortunately at the beginning of 2007 we are losing other two valuable members: Gianfranco Bertone is leaving Padua to join the AIP in Paris, while Jan Hamann has obtained his Ph. D in April 2007. We hope to maintain contact with the old members and are looking for replacements for both positions.

In 2007 we will continue to work in the field of Particle Physics and Cosmology. In particular we will study more in detail possible signatures of the decaying gravitino DM proposed in [9] and of the case of sneutrino NLSP.

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