

### Group Members (2007)

- Group Leader: Laura Covi (DESY)
- Postdoctoral Fellows: Florian Bauer (DESY) until September 2007  
Marieke Postma (DESY) from October 2007  
Gianfranco Bertone (INFN, Padova) until May 2007  
Felipe Joaquim (INFN, Padova) June-September 2007  
Pasquale Di Bari (INFN, Padova) from October 2007
- Doctoral and Diploma Students: Jan Hamann (DESY) until April 2007  
Michael Greife (DESY) from September 2007

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 2007 and early 2008.

---

### Indirect and Direct Dark Matter detection (G. Bertone, L. Covi, M. Greife)

Indirect Dark Matter (DM) detection plays an important role in the goal of identifying the particle which constitutes about 30% of the energy density of the universe. Strategies for indirect detection rely both in the observations in gamma-rays and in neutrinos, as reviewed in [1]. In general the most promising places to look for annihilating DM are where the density is large, and we studied such signals from the inner galaxy [2], where astrophysical processes can modify the DM profiles, and in ‘mini-spikes’ around Intermediate Mass Black Holes [3, 4].

Different is the case of a decaying DM particle, as is the case of the gravitino within models with R-parity violation [6], since in that case the signal is proportional to the density along the line of sight and not its square. Then the gamma-ray flux is expected to be more isotropic and therefore could be easily distinguished from the annihilating case [7]. There are very good prospects of detections of such a signal for the next generation of experiments like GLAST and non-detection will improve the bounds on the gravitino lifetime by a couple of orders of magnitude. Since the gravitino decays into a photon (or a gauge boson in general) and neutrino, we expect also a similar signal in the neutrino flux, but unfortunately this is much more difficult to disentangle from the atmospheric neutrino background [8].

If the Dark Matter is instead weakly interacting, direct detection of both the axial and scalar couplings would be crucial for identifying its nature [5].

### Inflation in SUGRA (L. Covi, M. Postma)

We completed at the beginning of the year the phenomenological studies on the inflationary models with a step-like change of the inflaton mass [10]. We found that, even if such models are still viable, the data do not seem to require the presence of features in the spectrum and that in any case degeneracies of the oscillation with standard cosmological parameters are virtually non-existent.

We are now concentrating on inflationary model-building within the context of Supergravity. In models derived from string theory, the problem of realizing inflation is always connected to the stabilization of all moduli fields and to the question of up-lifting the supersymmetric Anti-deSitter or Minkowski vacua to the observed de Sitter one. A popular type of scenario which

can achieve all these conditions is racetrack inflation, where the moduli stabilization is due to the presence of two or more gaugino condensates. We have studied such kind of models with supersymmetric D-term up-lifting [11]. We find that a spectral index  $n_s < 0.95$  appears to be a generic prediction of racetrack inflation models and we could explain such result by a simple analytic formula [12]. We also explored the interplay between the stabilization mechanism and the inflationary sector [13] and tried to implement chaotic inflation with different moduli stabilization mechanisms finding that a viable model can be obtained only at the cost of a fine-tuned moduli sector [14].

## Cosmology and neutrinos

Cosmology offers a very powerful tool in constraining the overall scale of the neutrino masses thanks to the effect of neutrino free-streaming on structure formation. These bounds though can be easily changed in non-standard cosmological scenarios; we have investigated for example how a running cosmological constant may relax those bounds and proposed ways to probe such kind of models in the near future [15]. On the model building side, we investigated in detail the neutrino masses and mixings and CP violation in a Grand-Unified SO(10) Model based on a 6D orbifold: we found that we can accommodate naturally even maximal or large mixings and explain the small hierarchy of neutrino masses as a consequence of the mismatch of the up and down quark mass hierarchies [16].

## Workshop "Early universe Thermometers"

In February this year we had the first HGF-Project Workshop organized in Padova by Pasquale Di Bari. During 3 days, we had plenary review talks by S. Matarrese, J. Lesgourges, M. Quiros, E. Roulet, H. Murayama and E. Kolb and many interesting talks on inflation, leptogenesis, dark matter and neutrinos in cosmology [17]. The meeting has been very successful and allowed to strengthen the link between the Padova and DESY groups.

## 2008 Plan (L. Covi, P. Di Bari, M. Grefe, M. Postma)

After the many changes within project members in 2007, we look forward to a more stable situation in 2008 and we will continue to work in the field of Particle Physics and Cosmology. We are planning to concentrate on inflationary model building, signals of gravitino Dark Matter at colliders and in neutrinos, and leptogenesis.

## References

- [1] G. Bertone,  
*Light from darkness: Searching for Dark Matter with gamma-ray and neutrino telescopes*,  
New Astron. Rev. **51** (2007) 321.
- [2] E. J. Ahn, G. Bertone and D. Merritt,  
*Impact of astrophysical processes on the gamma-ray background from dark matter annihilations*, Phys. Rev. D **76** (2007) 023517 [arXiv:astro-ph/0703236].
- [3] M. Fornasa, M. Taoso and G. Bertone,  
*Gamma-Rays from Dark Matter Mini-Spikes in M31*,  
Phys. Rev. D **76** (2007) 043517 [arXiv:astro-ph/0703757].

- [4] P. Brun, G. Bertone, J. Lavalle, P. Salati and R. Taillet,  
*Antiproton and Positron Signal Enhancement in Dark Matter Mini-Spikes Scenarios*,  
Phys. Rev. D **76** (2007) 083506 [arXiv:0704.2543 [astro-ph]].
- [5] G. Bertone, D. G. Cerdeno, J. I. Collar and B. C. Odom,  
*WIMP identification through a combined measurement of axial and scalar couplings*,  
Phys. Rev. Lett. **99** (2007) 151301 [arXiv:0705.2502 [astro-ph]].
- [6] W. Buchmüller, L. Covi, K. Hamaguchi, A. Ibarra and T. Yanagida,  
*Gravitino dark matter in R-parity breaking vacua*,  
JHEP **0703** (2007) 037 [arXiv:hep-ph/0702184].
- [7] G. Bertone, W. Buchmüller, L. Covi and A. Ibarra,  
*Gamma-Rays from Decaying Dark Matter*,  
JCAP **0711** (2007) 003 [arXiv:0709.2299 [astro-ph]].
- [8] L. Covi, M. Grefe, A. Ibarra and D. Tran,  
*Decaying Gravitino DM and neutrinos*,  
work in progress.
- [9] L. Covi and S. Kraml,  
*Collider signatures of gravitino dark matter with a sneutrino NLSP*,  
JHEP **0708** (2007) 015 [arXiv:hep-ph/0703130].
- [10] J. Hamann, L. Covi, A. Melchiorri and A. Slosar,  
*New constraints on oscillations in the primordial spectrum of inflationary perturbations*,  
Phys. Rev. D **76**, 023503 (2007) [arXiv:astro-ph/0701380].
- [11] P. Brax, A. C. Davis, S. C. Davis, R. Jeannerot and M. Postma,  
*D-term Uplifted Racetrack Inflation*,  
JCAP **0801** (2008) 008 [arXiv:0710.4876 [hep-th]].
- [12] Ph. Brax, S. C. Davis and M. Postma,  
*The Robustness of  $n_s < 0.95$  in Racetrack Inflation*,  
JCAP **0802** (2008) 020 [arXiv:0712.0535 [hep-th]].
- [13] S. C. Davis and M. Postma,  
*Successfully combining SUGRA hybrid inflation and moduli stabilisation*,  
JCAP **0804** (2008) 022 [arXiv:0801.2116 [hep-th]].
- [14] S. C. Davis and M. Postma,  
*SUGRA chaotic inflation and moduli stabilisation*,  
JCAP **0803** (2008) 015 [arXiv:0801.4696 [hep-ph]].
- [15] F. Bauer and L. Schrempp,  
*Relaxing neutrino mass bounds by a running cosmological constant*,  
JCAP **0804** (2008) 006 [arXiv:0711.0744 [astro-ph]].
- [16] W. Buchmüller, L. Covi, D. Emmanuel-Costa and S. Wiesenfeldt,  
*CP Violation and Neutrino Masses and Mixings from Quark Mass Hierarchies*,  
JHEP **0712** (2007) 030 [arXiv:0709.4650 [hep-ph]].
- [17] <http://www.pd.infn.it/~dibari/workshop.html>