Theory.

75. PRC Open Session
Hamburg, 11 April 2013

Thomas Konstandin
(particle cosmology)

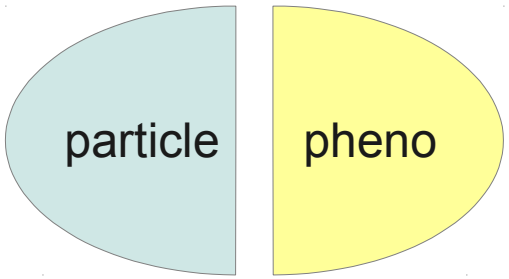
HELMHOLTZ ASSOCIATION

DESY

Structure.

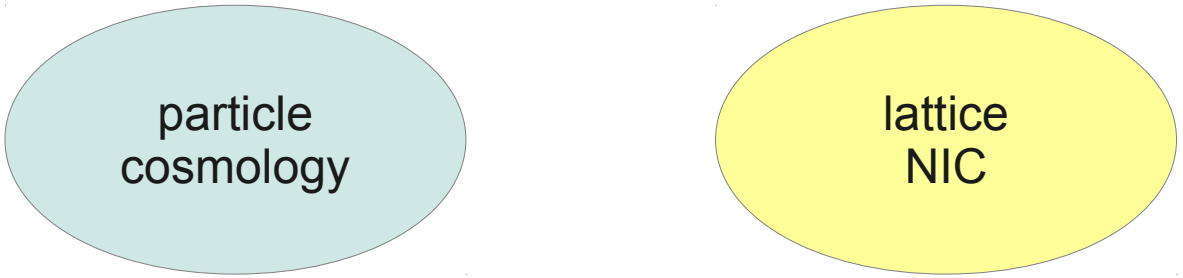
Hamburg

Zeuthen



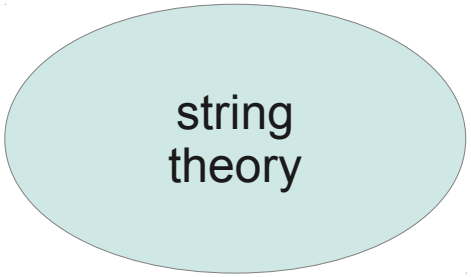
M. Diehl
J. Reuter
F. Tackmann
G. Weiglein
A. Weiler

J. Blümlein
T. Riemann
NN (June 2013)



W. Buchmüller
T. Konstandin
O. Lebedev
A. Ringwald
A. Westphal

K. Jansen
H. Simma
R. Sommer



I. Kirsch
V. Schomerus
J. Teschner

Funding.

Particles, Strings, and the Early Universe
Collaborative Research Center SFB 676

DFG SFB TR 9

DESY
Humboldt U Berlin
RTWH Aachen
KIT

DFG SFB 676

DESY
U Hamburg

GATIS

DESY
...

Conferences and Workshops.

main organization or co-organized

11-15 March 2013
Computer Algebra and Particle Physics School

18 - 20 April 2013
Monte Carlo for Beyond Standard Model Physics

6 - 8 May 2013
Helmholtz Alliance: SUSY Workshop 2013

27 -31 May 2013
ECFA Linear Collider Workshop 2013

15 - 19 July 2013
StringPheno 2013

2 – 6 September 2013
QCD @ LHC

11 – 13 September 2013
Non-equilibrium techniques in cosmology and condensed matter systems

24 – 27 September 2013
DESY theory workshop: Non-perturbative QFT: Methods and Applications

Teaching.

Lectures (WS12/13 + SS 13)

Standard Model and LHC Physics (U Hamburg)

(Grand) Unified Theories (U Hamburg)

Theoretical Cosmology (U Hamburg)

Introduction to Supersymmetry and Supergravity (U Hamburg)

Introduction to String Theory (U Hamburg)

Techniques of Feynman Diagram Calculations in Particle Physics (U Dortmund)

Quantenfeldtheorie und Einführung in die Elementarteilchen-Theorie (FU Berlin)

Einführung in die Teilchenphysik (U Hannover)

Teaching & Training:

LHCPHENOnet

DFG GrK 1670 / GrK 1504

Summer School on Moduli Spaces in Algebraic Geometry

Helmholtz Intern. Summer School on Cosmology, Strings and New Physics

News: GATIS.

activities:

25-28 February 2013, DESY
Kickoff workshop

11-15 March 2013, ICTP Trieste
Mathematica Summer School on Theoretical Physics

19-23 August 2013, Utrecht
IGST Conference

network members:

DESY - Theory Group (coordinator)
Humboldt Universitat
Durham University
Universidade do Porto
King's College London
NORDITA Stockholm
Saclay/CNRS

+ 4 associated partners

MARIE CURIE ACTIONS

DESY

News: Wolfgang Pauli Centre.

PIER

Eine Partnerschaft der Universität Hamburg und DESY

Activities:

17 April 2013
Inauguration Symposium

- WPC blackboard seminars
- annual Wolfgang-Pauli-Lecture by a non-tenured researcher
- workshops on new ideas at the intersection of the present research fields
- special lectures by visiting professors

Collaboration of the various theory groups in Hamburg

I.+II. Institute for Theoretical Physics
Sternwarte Hamburg
DESY Theory group
Center for Free-Electron Laser Science
The Institute of Laser Physics

particle physics	**condensed matter**
astrophysics and cosmology	**quantum optics**
mathematical physics	**chemical physics**

Particle Cosmology.

- Staff:
  - Wilfried Buchmüller
  - Thomas Konstandin
  - Oleg Lebedev
  - Andreas Ringwald
  - Alexander Westphal *
- ~ 10 students #

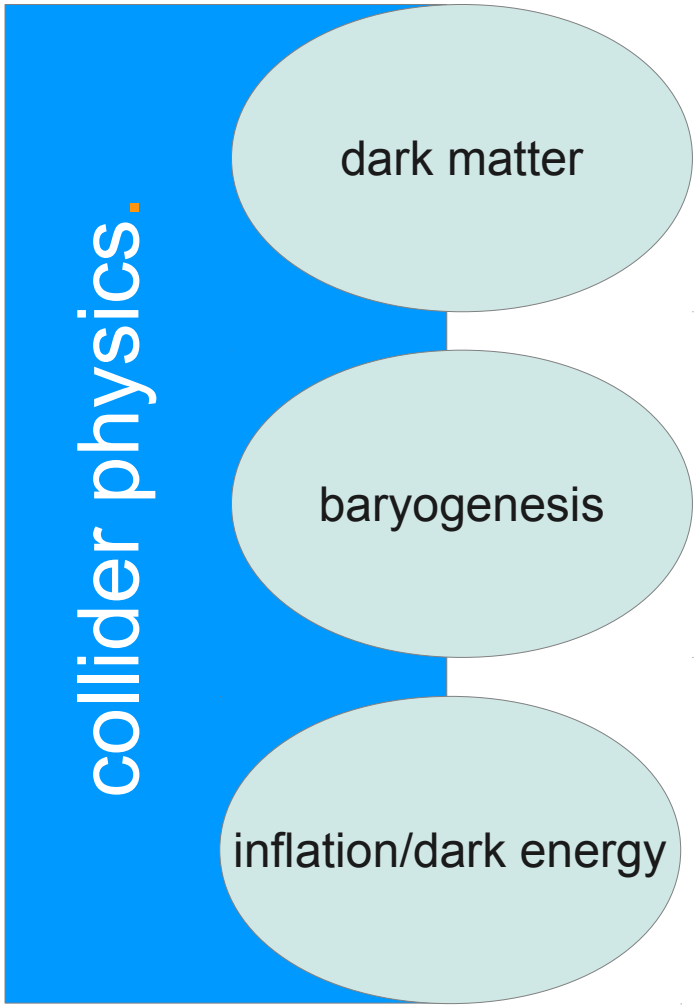
Joachim Herz Stiftung

- Fellows:
  - Ido Ben-Dayan *
  - Felix Brümmer *
  - Francisco Pedro *
  - Mathias Garny
  - Kohei Kamada *
  - Sara Rydbeck
  - Patrick Vaudrevange *
  - Martin Winkler

* SFB, HGF, LEXI

DESY

Research topics.



Low energy cosmology
- axions and other WISPs

Electroweak cosmology
- electroweak baryogenesis
- gravitational waves
- „hidden Sector“ WIMP DM
- Higgs inflation

GUT cosmology
- GUTs in extra dimensions
- leptogenesis
- gravitinos

Stringy cosmology
- string inflation
- heterotic/type IIB string theory

WISPy dark matter.

WISP = weakly interacting slim particle

Dark matter candidates with sub-MeV masses.

- axion like particles (ALPs): Scalars (ϕ) that are ubiquitous in string theory. Couple to SM gauge fields via

$$\mathcal{L} \ni g\,\phi F_{\mu\nu}\tilde{F}^{\mu\nu}$$

- hidden photons: Massive U(1) gauge bosons (X^μ) that kinetically mix with EM photons.

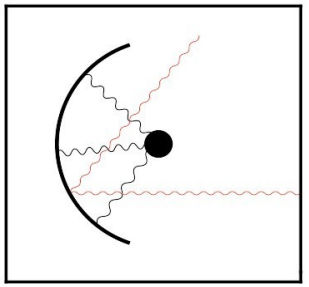
$$\mathcal{L} \ni -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{1}{4}X_{\mu\nu}X^{\mu\nu} - \frac{\chi}{2}X_{\mu\nu}F^{\mu\nu} + m_X^2 X^\mu X_\mu$$

WISP detection.

Proposal of a dish antenna experiment for WISP detection

Searching for WISPy Cold Dark Matter with a Dish Antenna

D. Horns, J. Jaeckel, A. Lindner, A. Lobanov, J. Redondo, A. Ringwald (1212.2970)

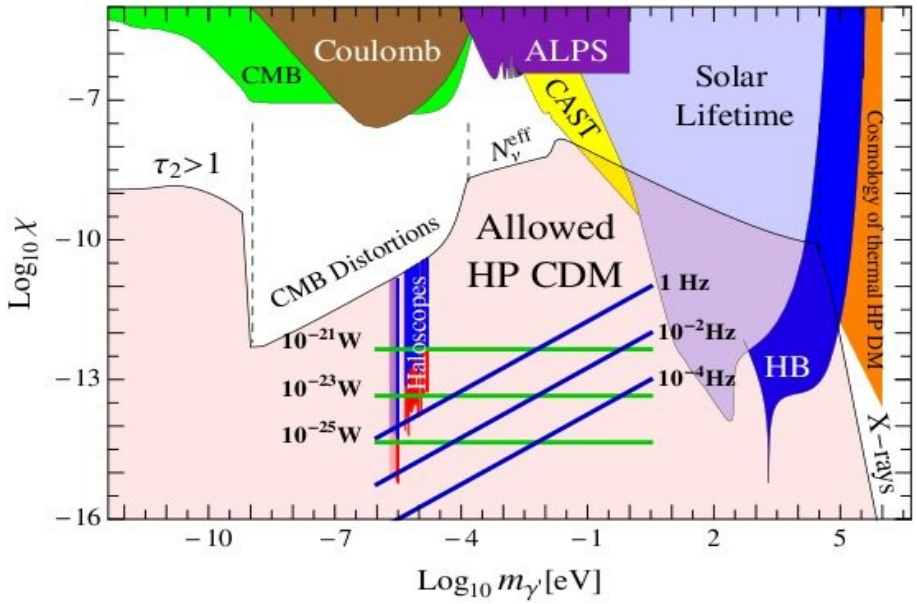


Hidden photon dark matter predicts a ambient hidden photon density

Close to conducting material, this induces EM photon densities that can be observed.

The experiment is rather insensitive to the mass.

This technique can also be used to observe ALPs if a magnetic field is applied.



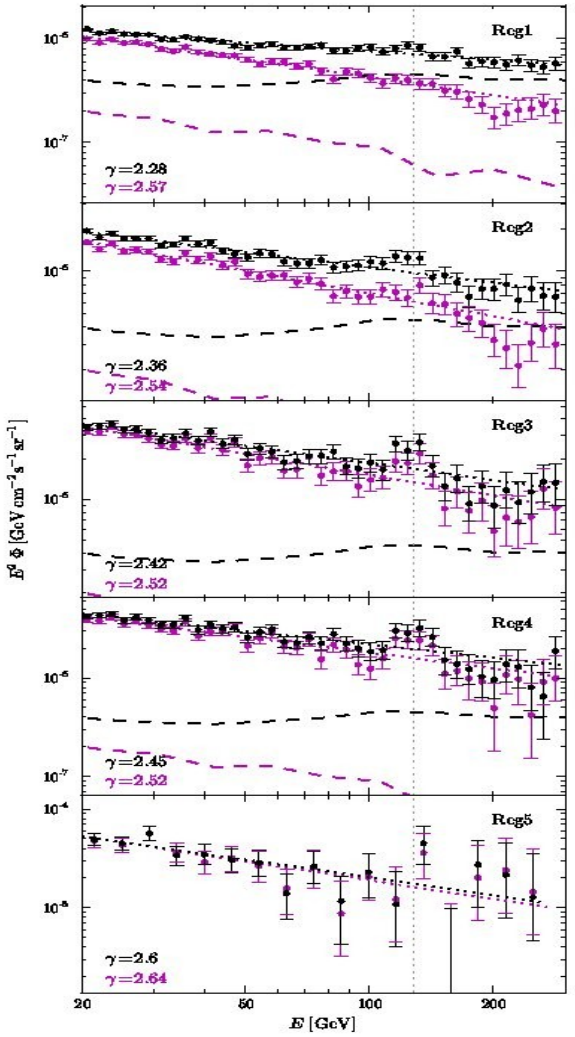
Dark matter vs Fermi data.

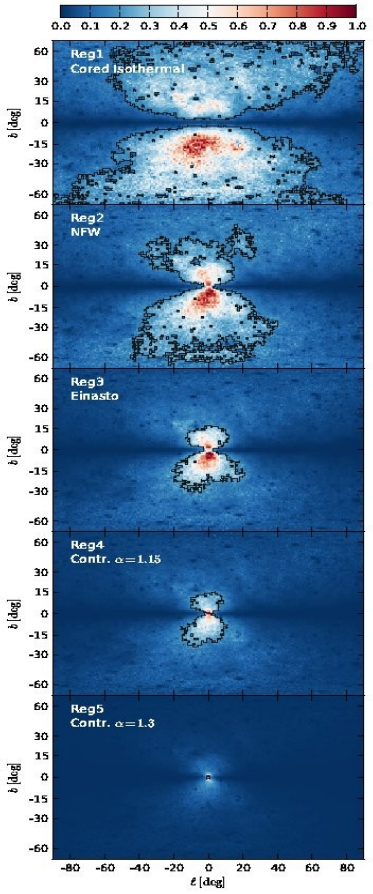
Weniger(-Bringmann-Huang-Ibarra-Vogl)-line.

Gamma-lines are a smoking gun signal for dark matter.

On the other hand, dark matter is dark and decays into gammas only at loop level.

If this signal is statistically confirmed, is it compatible with dark matter?





MSSM DM vs Fermi data.

Compatibility of continuum vs line

$$BR_\gamma > 0.5\%$$

- Annihilating dark matter:

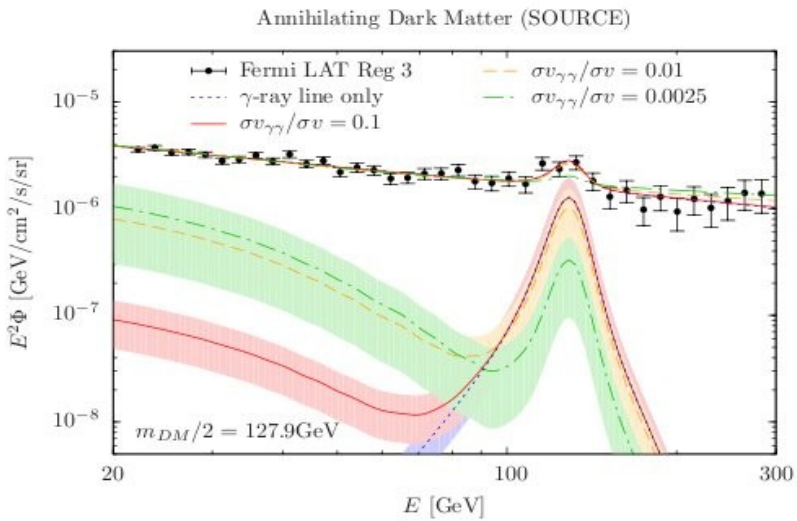
  neutralino DM excluded

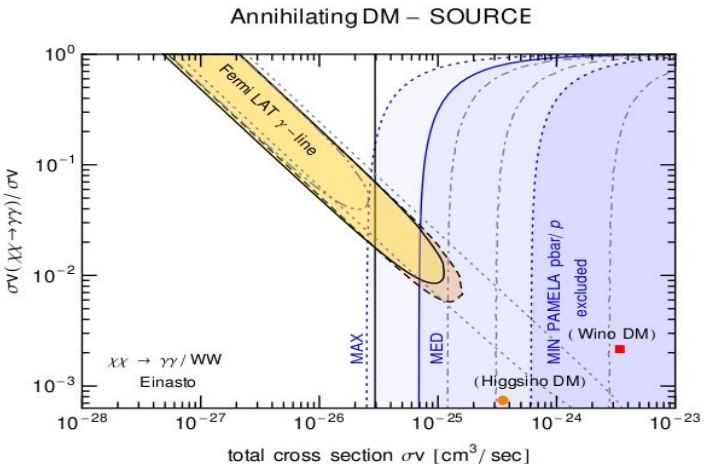
- Decaying dark matter:

  possible in the MSSM with R-parity violation (gravitino DM).

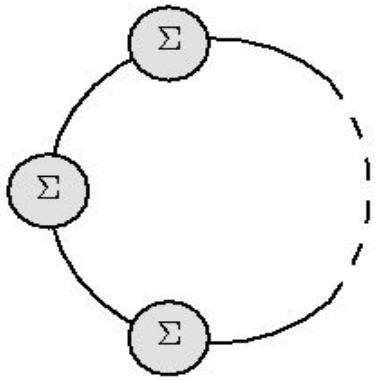
  excluded for standard DM halo profiles

Decaying vs Annihilating Dark Matter in Light of a Tentative Gamma-Ray Line
W. Buchmuller, M. Garny (1206.7056)





Gauge issues in Thermal Field Theory.



daisy diagrams

Many calculations at finite temperate are based on the effective potential (~ free energy) of the Higgs field.

The perturbation theory of the effective potential is not IR save due to thermal effects and massless (gauge) particles

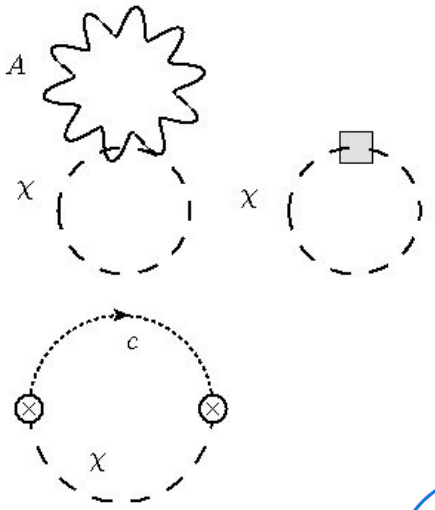
-> resummation -> gauge dependence ?

Some observables (tunnel rates, sphaleron rates) can potentially have a strong gauge dependence.

On the gauge dependence of vacuum transitions at finite temperature
M. Garny, T. Konstandin (1205.3392)

Effective potential and Nielsen identities in R_ξ gauge.

Resummation of the relevant set of diagrams. Explicit demonstration of the gauge independence.



Electroweak vacuum.

Assuming a Higgs mass of ~ 125 GeV, the running of the quartic coupling in the SM can be studied (NLO)

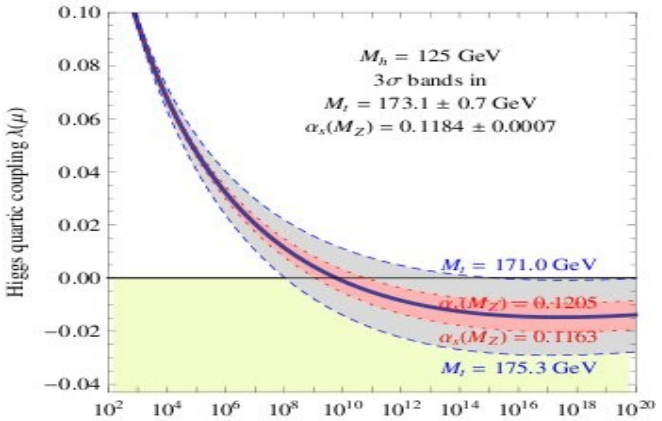
Even though the EW vacuum is meta-stable, this introduces a fine-tuning in the initial conditions.

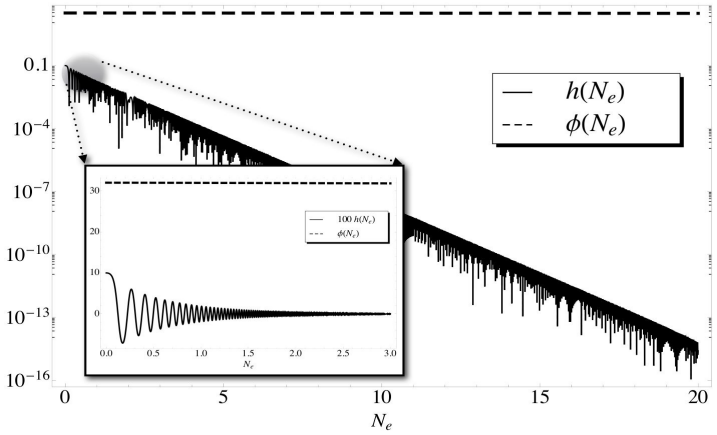
Higgs coupling to the inflaton
Metastable Electroweak Vacuum: Implications for Inflation
O. Lebedev, A. Westphal (1210.6987)

Already a small coupling between the Higgs and the inflaton

$$\mathcal{L} \ni m^2\phi^2 + \xi h^2\phi^2$$

introduces a effective Higgs mass that drives the Higgs field to small values during inflation.





Summary.

The DESY theory group:

- covers a broad spectrum of timely topics in HEP
- center for theoretical physics in Germany/Europe:
  organizing conferences, fellow program, networks
- traditionally strong connection to experimental programs and
  mathematics: SFB TR9, SFB 676, ZMP
- well integrated in Universities and in educational activities