C4:Unified Dark Matter and Energy

H. Dreiner and H.P. Nilles

10^{-32} eV $\sim M_Q = \frac{E_{vac}^2}{M_{pl}}$

10^{-5} eV

10^{-3} eV $\sim E_{vac}^{1/4}$

1 MeV

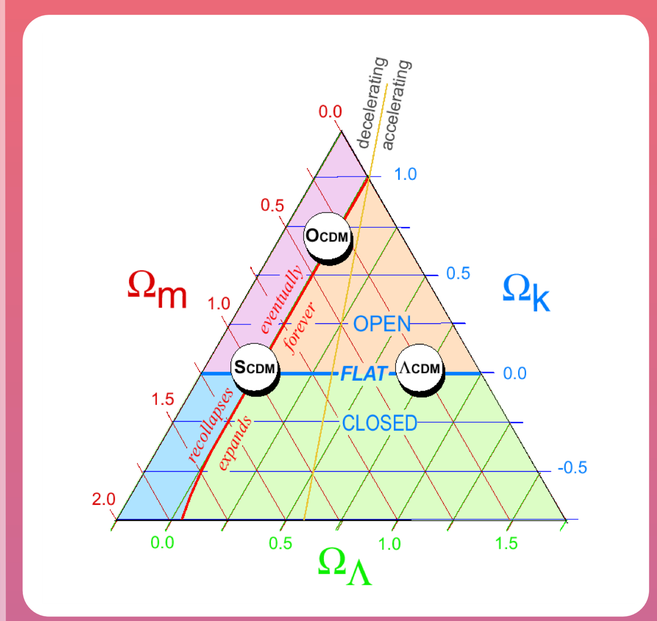
1 TeV

10^{9} GeV

10^{12} GeV

10^{18} GeV $\sim M_{pl}$

Dark Energy



Quintessential Axion

Kim-Nilles, Phys.Lett.B553:1-6,2003.

The model-independent axion in string theory typically has $f_Q \sim M_{pl}$ and therefore $M_Q \sim 10^{-32}\,eV$

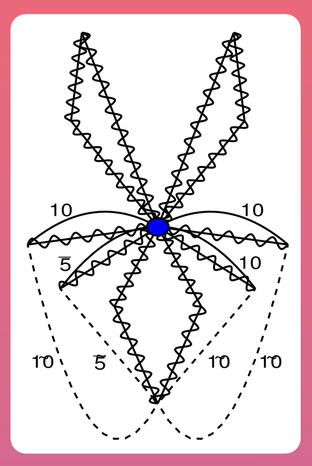
The axion can cause present day acceleration if it has not yet reached the minimum of its potential and its energy density is of order $(10^{-3}eV)^4$: a very shallow potential.

Further implications of this set-up will be studied: stability of the potential, realisations in string theory and the relation to the QCD Axion in the mass range

$$10^{-6}eV \lesssim m_a \lesssim 1\,eV$$

Multiaxion system

Kim-Nilles, JCAP 0905:010,2009.



A quintessential axion can be combined with a composite QCD axion from hidden sector squark condensation.

Such a particle could, in addition, serve as a Cold Dark Matter candidate.

We plan to investigate possibilities to realise this mechanism in concrete BSM theories.

Dark Matter

Axino

Dreiner-Poletanovic, to appear.

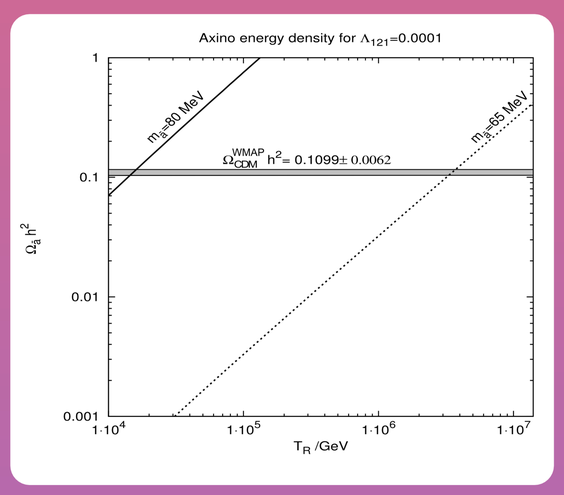
The DFSZ Axino can easily be embedded in MSUGRA with RPV. It decays in: $\tilde{a} \longrightarrow \gamma\,\nu,\ e^+e^-\,\nu,\ \pi^{\pm}l^{\mp}$

But $\tau \sim \frac{(\mathrm{Mix})M_W^{2(4)}}{M_{\tilde{a}}^{3(5)}}$

τ large ➡ DM Candidate for RPV-SUSY.

Studied for one lepton number violation ($LL\bar{E}$) coupling at benchmark point SPS1a.

We will study Axino properties via analysis of RPV couplings: $LL\bar{E}$ & $LQ\bar{D}$ at all benchmark points and connection with neutrinos.

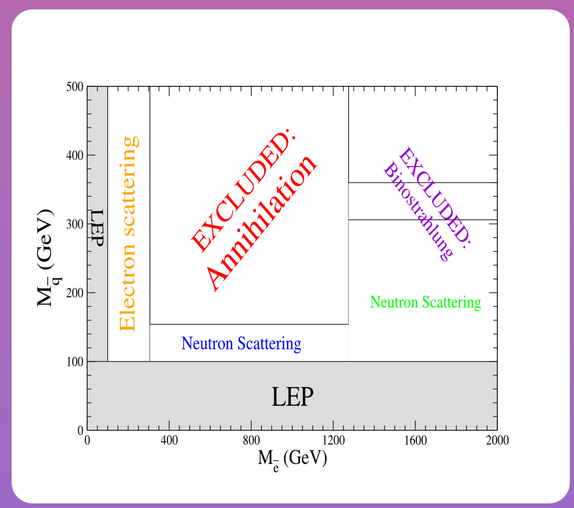


Neutralinos

Dreiner et al. Phys.Rev.D80:035018, 2009.
Eur.Phys.J.C62:547-572,2009. ArXiv:0812.1594[hep-ph].

$M_{\chi^0} = 0$ experimentally allowed: Supernovae, Collider, Meson decays, Hot Dark Matter.

We will continue investigation of the properties of a very light neutralino. How well can we determine its mass and couplings at the LHC?

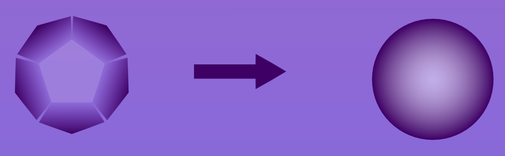


Axion Window

Accions

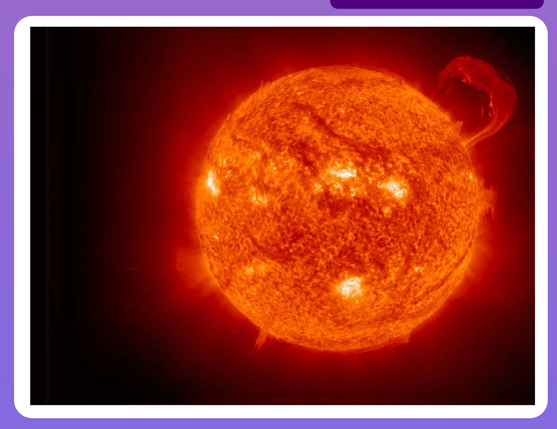
Choi-Nilles-Ramos Sanchez-Vaudrevange, Phys.Lett.B675:381,2009.

Accidental global symmetries can arise in string theory compactifications, as low energy remanants of discrete symmetries.



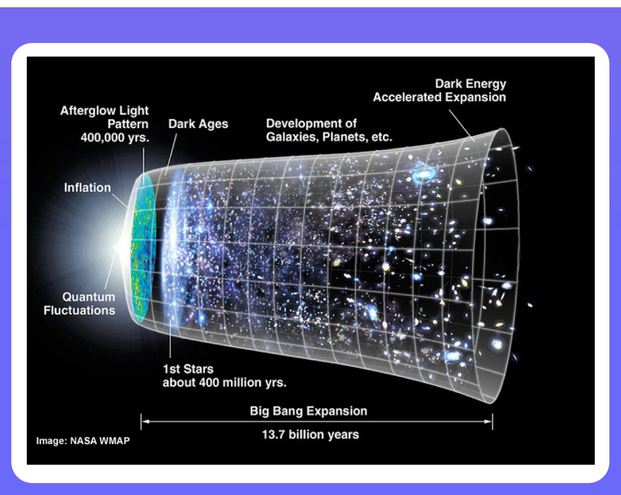
The associated accions represent perfect candidates for a solution of the strong CP problem as well as Cold Dark Matter. Moreover, they can play a decisive role in early and late time (accelerated) expansion of the universe, as inflatons or quintessential accions, respectively. This unified picture of dark matter, dark energy and cosmological expansion will be studied in the project.

Solar Axions



$$10^9 GeV \lesssim f_a \lesssim 10^{12} GeV$$

Axionic Inflation

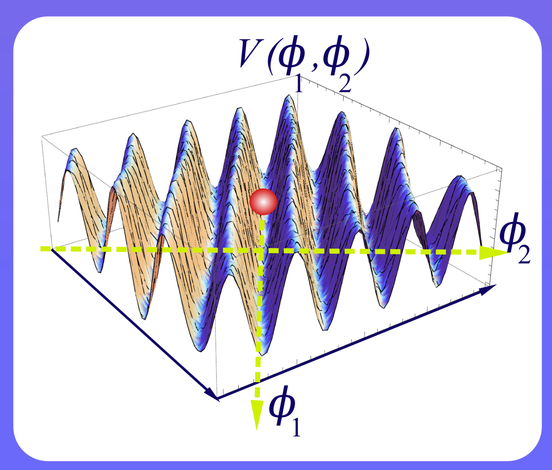


Completing Natural Inflation

Kim-Nilles-Peloso, JCAP 0501:005,2005.

Considering two axion fields ϕ_i playing a role in inflation we can achieve:

$$f_{eff} \gtrsim M_{pl} \quad \text{while} \quad f_{\phi_i} \lesssim M_{pl} \quad ,$$

thus avoiding some problems of natural inflation. This can be generalized to many fields (N-flation).

Along the same lines we plan to investigate Accionic-Inflation in connection with the question of the origin of dark matter and dark energy.