WG1 - WISPs Model Building Plans & Organization

Michele Cicoli + Ilaria Brivio

Università & INFN Bologna

WG1 targets in a nutshell

Tasks

- coordinate theory advancements and promote knowledge exchange among groups
- bring together diverse communities in a synergic way, to address open issues with different approaches
- give theoretical guidance to experimental searches

Top-down

start from **concrete BSM scenarios**
[string theory, axion models…]

determine UV-motivated WISP properties
how many and which WISPs are produced?
when is a QCD axion produced?
what are natural values for masses and couplings?

Bottom-up

identify UV scenarios
compatible with observation

start from phenomenological study
in **Effective Field Theory**

↪ see scientific talk this afternoon

Organization & Internal communication

WG Leader: Michele Cicoli michele.cicoli@unibo.it
WG Co-Leader: Ilaria Brivio ilaria.brivio@unibo.it

Google Group “CosmicWISPers WG1”
https://groups.google.com/g/cosmicwispers-wg1/

- 52 registered members so far
- mailing list: cosmicwispers-wg1@googlegroups.com
- address book visible to all members

WG1 Monthly meetings

- virtual format (zoom)
- Mondays 2pm. will start in March.
- about **1h30** long:

  3 x 20’ **talks** by WG1 members, to present research interests and activities
  30’ **discussion**

Goal for the first year:

get to know each other & stimulate physics discussions

format can be revised in the future.
we can: invite external speakers, organize by topics, target specific recent papers…

image: Flaticon.com

Topical Meetings

plan to organize in-person / hybrid Topical Meetings starting next year

possible topics:

- the **QCD axion window** in the axion/ALP parameter space
- the **DM window** in the ALP parameter space
- properties of **ALPs from string** compactifications
- Hidden photons
- … collecting suggestions!

WG1 reports

scheduled deliverables:

- [month 12] **draft report** on theory and pheno
- [month 24] **interim report**
- [month 48] **final report**

possible content:

- catalogue of WISPs and their properties from TH and pheno points of view
- dictionary between them
- overview of BSM scenarios WISPs emerge from
- ...

Other Activities

- Short Term Scientific Missions
  to foster new collaborations between groups
- Cosmic WISPers Colloquia & Journal Club
- Theory courses at Training Schools
- Outreach activities
- Joint meetings/activities with other WGs

WG1: Main goal

Main goal:

Determine nature, number, masses and couplings of WISPs with applications to particle physics, cosmology and astrophysics via 2 complementary approaches:

1) Top-down: restrict WISP models from UV consistency (string theory)
   - → see talk by Westphal on ALPs from strings
   - → see talks by Goodsell on hidden photons from strings

2) Bottom-up: indication of WISP models promising for pheno
   - → see talk by Di Luzio on QCD axion model building

WISPs and UV physics

- WISPs are promising to test UV physics and WISPs need UV physics for consistency
- Several questions with no answer without UV completion:

1: What is the origin of QCD axion shift symmetry?
2: What dynamics breaks $U(1)_{PQ}$ spontaneously and sets f_a ?
3: Is f_a related to some physical scale M_p, M_s, M_{kk}, M_{GUT}, M_{soft}?
4: What dynamics breaks $U(1)_{PQ}$ explicitly and sets m_a?
5: Is m_a generated by QCD instantons or by other effects? (string instantons, fluxes, ….)
6: What solves the axion quality problem?
7: How is the axion produced in the early universe?
8: Can the axion be dark matter or dark radiation?
9: How many ALPs can arise?
10: What is the parameter space of f_a and m_a for ALPs?
11: What can be the role of ALPs in phenomenology?
Inflation? Dark matter? Dark radiation? Quintessence? Astrophysical signals? ……
12: How are ALP f_a and m_a statistically distributed in the string landscape?
13: Are there UV correlations among ALP f_a and m_a and different physics?
like supersymmetry breaking, inflation, dark matter, dark radiation, etc…
14: What are the properties of hidden photons with kinetic mixing with ordinary photons?
15: Can we build from string theory fully consistent WISP models?
instead of just string-inspired scenarios
16: Can we study WISPs in non-perturbative corners of string theory?
17: ……

WISPs as a way to test string theory?

- String theory (like QFT) is a framework, not a model (like SM)
- Generic features: strings and extra dimensions but unlikely to be tested with accelerators
  → focus on low-energy 4D applications

- String theory yields a landscape of 4D vacua
  i) are they actual solutions?
  ii) how are they connected?
  iii) is there a selection principle?
  } need full quantum dynamics of string theory

- 2 approaches in absence of complete answers:

1) Focus on a vacuum
   - pro: explicit computation
   - con: lamppost effect

2) Extract statistics
   - pro: find generic features
   - con: trustability of results (moduli stabilisation?)

→ ultra-light ALPs: generic feature of controlled 4D EFTs from strings
which is not really motived from QFT point of view

→ WISP model building is a promising arena to test string theory