

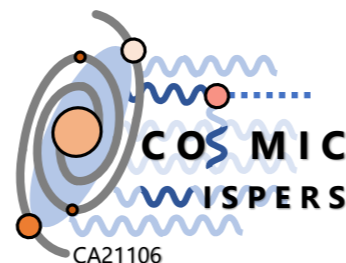
WWII

WISPs Dark Matter and Cosmology plans and organisation

Javier Redondo
COST21106 kick off meeting
LNF 23-24/02/2023



Dep. Theoretical Physics
Universidad de Zaragoza



MAX-PLANCK-GESELLSCHAFT
MPP Munich

COST : big picture

Bring together European WISP researchers to :



COST : big picture

In detail: 4 years of funding (~500,000 total), for :



Our working group 2:

- **WISP (axion) dark matter and cosmology**
- **Working Group ``leaders" (we'd prefer coordinators)**



*Nicholas Rodd
CERN
Dark matter indirect detection.
EFTs, axions, statistics, and collider physics.
<https://nickrodd.com>*



*Javier Redondo
Universidad de Zaragoza, Spain
Max Planck for Physics, Munich
BSM @ Low energy physics,
Axions, Dark matter, other WISPs*

Our working group 2:

WG 2: WISPs Dark Matter and Cosmology. This WG aims to study the multi-faceted and diverse cosmology of WISPs. Many WISPs are cold DM candidates whose production mechanisms may be non-thermal and depend on the dynamics of phase transitions or topological defects (as is the case of the QCD axion) [Sikivie (2008)]. This WG aims to identify and study the production mechanisms for WISPs DM, in order to reliably compute the DM relic density. In the case of the QCD axion, the relic density depends on the dynamics of two phase transitions, the second being the QCD Phase Transition, when the axion mass turns on. The WG would explore what lattice gauge theory can tell about this temperature-dependent axion mass [Borsanyi (2016)]. If the Peccei-Quinn symmetry is restored after inflation, the DM axion production from cosmic string decays has a dominant role [Gorghetto (2018)]. The WG will study the axion relic abundance from this mechanism and the production of miniclusters. It will study how WISP DM grows Large Scale Structures, and explore whether it generates distinct features that could allow to distinguish WISPs DM from WIMPs. The WG will also explore the cosmological signatures of WISPs as subleading hot DM. In this context, it has been recently pointed out [Di Luzio (2021)] that the current computations of the mass bounds on axion hot dark matter are not reliable since they are based on an extrapolation of the axion-pion interaction in a range where chiral perturbation theory breaks down. The WG will find a strategy to derive a reliable hot dark matter axion mass bound using lattice QCD techniques.

Our working group 2:

WG 2: WISPs Dark Matter and Cosmology. This WG aims to study the multi-faceted and diverse cosmology of WISPs. Many WISPs are cold DM candidates whose production mechanisms may be non-thermal and depend on the dynamics of phase transitions or topological defects (as is the case of the QCD axion) [Sikivie (2008)]. This WG aims to identify and study the production mechanisms for WISPs DM, in order to reliably compute the DM relic density. In the case of the QCD axion, the relic density depends on the dynamics of two phase transitions, the second being the QCD Phase Transition, when the axion mass turns on. The WG would explore what lattice gauge theory can tell about this temperature-dependent axion mass [Borsanyi (2016)]. If the Peccei-Quinn symmetry is restored after inflation, the DM axion production from cosmic string decays has a dominant role [Gorghetto (2018)]. The WG will study the axion relic abundance from this mechanism and the production of miniclusters. It will study how WISP DM grows Large Scale Structures, and explore whether it generates distinct features that could allow to distinguish WISPs DM from WIMPs. The WG will also explore the cosmological signatures of WISPs as subleading hot DM. In this context, it has been recently pointed out [Di Luzio (2021)] that the current computations of the mass bounds on axion hot dark matter are not reliable since they are based on an extrapolation of the axion-pion interaction in a range where chiral perturbation theory breaks down. The WG will find a strategy to derive a reliable hot dark matter axion mass bound using lattice QCD techniques.

Our working group 2:

WG 2: WISPs Dark Matter and Cosmology.

WISPs as dark matter candidates

Production mechanisms

Axion Thermal mass (lattice, ChiPT)

Cosmic string decays

Effects on Large and small-scale structure

hot DM (lattice, ChiPT)

In practice

- **Bring together scientists around WISPy Dark Matter & Cosmology**
- **Accelerate CURRENT research directions**
- **Create NEW research directions**
- **Identify bottlenecks (for CURRENT and NEW directions)**
- **widen the necks**
- **Identify key expertise, invite to the network**

legacy, scientific outreach, accountability

- **Produce reports on state of the art WISP dark matter and cosmology**
 - **Draft (year 1)**
 - **interim (year 2)**
 - **final (year 4)**

The aim is NOT to produce another snowmass-type document

We would like it to be new, exciting, new perspectives, new connections

Bold idea: perhaps connect it to the schools?

Snowmass 2021 White Paper Axion Dark Matter

J. Jaeckel¹, G. Rybka², L. Winslow³, and the Wave-like Dark Matter Community ⁴

¹Institut fuer theoretische Physik, Universitaet Heidelberg, Heidelberg, Germany

²University of Washington, Seattle, WA, USA

³Laboratory of Nuclear Science, Massachusetts Institute of Technology, Cambridge, MA, USA

⁴Updated Author List Under Construction

- Plenty of information available, executive summary of axion cosmology

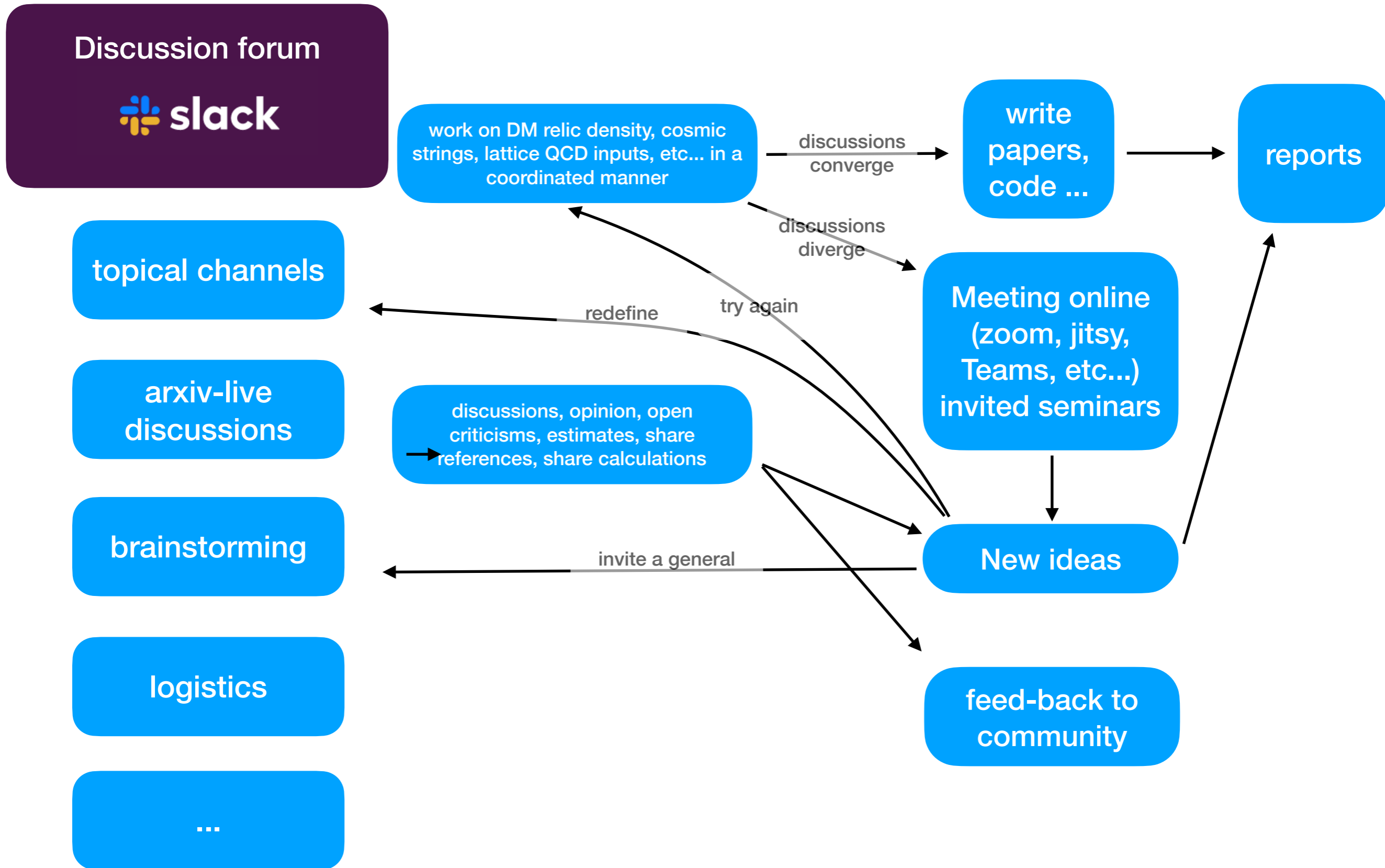
4	Axion Cosmology	12
4.1	Axion creation mechanisms	12
4.1.1	The Pre-Inflation Scenario	14
4.1.2	The Post-Inflation Scenario	15
4.1.3	Thermal Production and Evolution	15
4.2	Late-Time Structure Formation and the Local Properties	16

Initial plans

- **Establish a discussion forum**
- **Organize focussed meetings on specific topics**
- **Widen the community**

**We do not plan (yet) a structure for the reports,
let it emerge from the discussions and interest of the community**

Plans 1/3



WISP-WG2

- Hilos de conversaciones
- Mensajes directos
- Menciones y reacciones
- Borradores y enviados
- Slack Connect
- Más

Canales

- # general
- # kick-off-meeting-23-24-feb
- # paper-discussion
- # random
- Añadir canales

Mensajes directos

- Javier Redondo tú
- alessandromirizzi
- Amelia Drew, Giovanni Pier...
- Andrea Caputo
- Christoph Weniger
- Daniele MONTANINO
- Jernej F. Kamenik
- juan
- Mario Reig
- Maurizio Giannotti
- Nick Rodd
- Añadir compañeros de equ...

kick-off-meeting-2...

kick-off-meeting-23-24-feb

11

Martes, 14 de febrero

Javier Redondo 09:06
definió la descripción del canal: Organisation about the Kick-off-meeting Feb 2023

Javier Redondo 09:08
Hi all, I set up this to discuss the organisation of the kick-off meeting next week. After the meeting we can just easily delete it.

The webpage of the meeting is here : <https://agenda.infn.it/event/33570/>

Agenda (Indico)
Kick-off Meeting of COST Action COSMIC WISPerS (CA21106) (575 kB)



Patricia Diego 09:11
se ha unido a #kick-off-meeting-23-24-feb.

Javier Redondo 09:17
we are currently discussing the scheduling of the talks. As you can see there are 4 events particular to our WG2:

1. Thursday morning, A talk about plans and organisation
2. Thursday afternoon, Talk about state of the art physics
3. Thursday late afternoon, WG2 Discussions 18-19
4. Friday morning, time for our 3 invited talks ([@Giovanni Pierobon](#) on Axion Miniclusters and voids, [@Patricia Diego](#) on Cosmic ALP birefringence, [@Amelia Drew](#) on Axion AMR simulations)

We have discussed with [@Andrea Caputo](#) and [@Nick Rodd](#) that Unfortunately, the talks on Friday (4) overlap with all invited talks of the other WGs in particular with the Astro WG. Of course, we would like to attend them all!!!! We think that these will be the most substantial talks, about physics and details so why restricting the audience?

Well, we cannot change the whole structure now, but we can probably reshuffle in our slots ... there are some ideas on the road but please post yours, we need to decide asap

Nick Rodd 09:18
se ha unido a #kick-off-meeting-23-24-feb.

Rich text editor toolbar with icons for Bold (B), Italic (I), Underline (U), Link (chain), Bulleted list (list), Numbered list (list), Code (code), and Insert (document).

Enviar un mensaje a #kick-off-meeting-23-24-feb

Rich text editor input area with icons for Attach (paperclip), Video (camera), Emoji (smiley), Mention (@), and Text color (Aa).



Sigue conectado a WISP-WG2 desde cualquier lugar

Conéctate a la aplicación móvil

Omitir todos los consejos

will it work? let us try for a couple of months ...

Plans 2/3

- **Focused workshops on very concrete topics:**

- **input from lattice QCD into axion (WISP) cosmology?**

- QCD potential away from ~ 0 , axion thermal width, couplings,

- **Important steps towards an accurate computation of m_a for post-inflation PQ**

- Numerical simulations, HPC, AMR, theoretical modeling, etc...

- **What needs to be done to identifying WISP signals in LSS?**

- Birefringence, PS, Ly-alpha, strings, ...

- **Community decides using the forum**

Plans 3/3

- currently we are ~100 people in the WG2 mailing list
- Identify new plausible collaborators
 - We may have ~exhausted the EURO axion ``field'', but not the
 - lattice QCD community
 - Cosmology community
 - Early Universe Phase transitions
 - Computational cosmology/structure formation community
 - Theoretical cosmology
 - Solid-state?
 - Scan by institution, intuitions, search for breakthroughs in fields
- Discuss most urgent/needed fields, recruit new scientists?

1st WG2 meeting

Nice attendance

~ D'Oro, Rodd, Diego, Pierobon, Lella, Terças, Lombardo, Sala, Sigl, Mirizzi, Schwetz, Tamaro, Lucente, Demir Pulice, Bernal, Masrh, Mevemsek, Cogollos, Kaltschmidt, O'Hare, Redondo, Gerbino, Lattanzi, Gorghetto, Cembranos

Very heterogenous community

CTA, warm DM, astro-signatures, CMB birefringence, axion DM simulations, Miniclusters, ALP pheno, SN, ALPs in plasmas lattice QCD, ALP star pheno, HE astro, dark matter, a-gamma mixing in B-fields, neutrino astro, neutrino cosmo, machine-learning WISPs in astro/cosmo, DM from Higgs stability, vector fields, WIMPs, phase transitions, haloscopes, small scale distribution of DM, CMB on ALPs, neutrinos, precision QCD, ultralight dark matter ...

- some students, young postdocs, but not nearly enough :-)

Some suggestions

- common calendar, compatibility of events
- common topics, coordination (miniclusters?)

Conclusions



- **Widen the network**
- **Forum**
- **Topical workshops**
- **Doing relevant science**
- **Plant the seeds for even more relevant science**