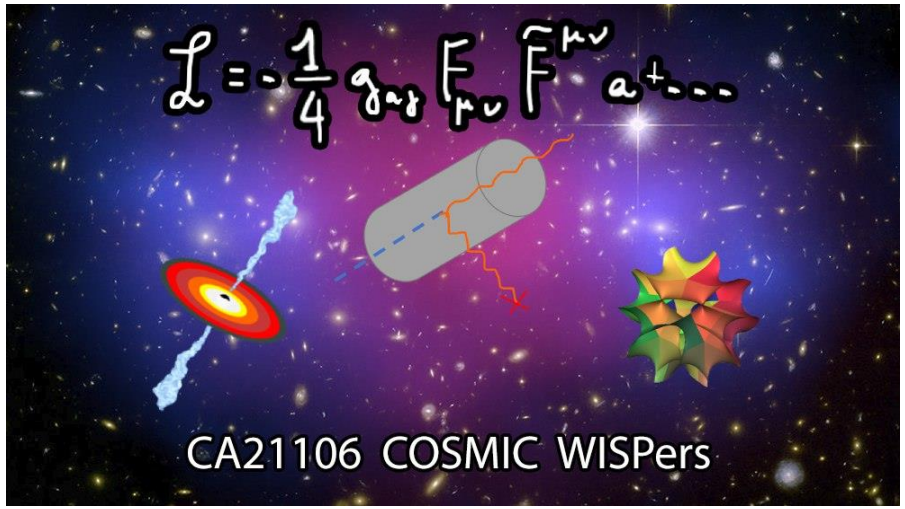
3rd CA21106 General Meeting, Sofia, 9-12 September 2025

COST ACTION CA21106

COSMIC WISPers in the Dark Universe:

Theory, astrophysics and experiments

Alessandro Mirizzi
(Bari Univ. & INFN, Italy)



Funded by the European Union

Inma Dominguez

Inma is Professor of Astronomy and Astrophysics at the University of Granada (Spain). She obtained her PhD from the University of Barcelona, and has worked on Type Ia Supernovae since her doctoral thesis and on stellar evolution since her postdoc at the Istituto di Astrofisica Spaziale (Frascati, Italy). Her works include the study of Pop. III intermediate mass stars, identifying their contribution to the early chemical enrichment of the Universe; the analysis of the AGB phase as an astroparticle laboratory; the derivation of bounds for the axion coupling constants to fermions and photons; and a series of studies about the impact of progenitor properties on observable properties of Type Ia supernovae, which are fundamental for their cosmological applications. Together with other colleagues, she founded in 2010 the Azarquiel School of Astronomy: a scientific bridge between Eastern and Western cultures.

She considers herself a nomad, needs to be in the open air, hiking, cycling, skiing, and likes traveling, specially to remote places... back at home, she enjoys being with her family and friends and reading.

Astronomy & Astrophysics manuscript no. aanda
August 26, 2025

The Impact of Axion-Like Particles on Late Stellar Evolution

From Intermediate-Mass Stars to core-collapse Supernova Progenitors

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Received XXX; YYY

ABSTRACT

Context. Stars with masses ranging from 3 to 11 $M_\odot$ exhibit multiple evolutionary paths. Less massive stars in this range conclude their evolution as carbon-oxygen (CO) white dwarfs. However, those that achieve carbon ignition before the pressure by degenerate electron halts the core contraction may either form massive CONe/ONe white dwarfs, or undergo an electron-capture supernova, or photo-disintegrate neon and proceed with further thermonuclear burning, ultimately leading to the formation of a gravitationally unstable iron core.
Aims. An evaluation of the impact of the energy loss caused by the production of axion-like-particles (ALPs) on evolution and final destiny of these stars is the main objective of this paper.
Methods. We compute various sets of stellar models, all with solar initial composition, varying the strengths of the ALP coupling with photons and electrons.
Results. As a consequence of an ALP thermal production, the critical masses for off-center C and Ne ignitions are both shifted upward. When the current bounds for the ALP coupling strengths are assumed, the maximum mass for CO WD progenitors is about 1.1 $M_\odot$ heavier than that obtained without the ALP energy loss, while the minimum mass for a core collapse supernova (CCSN) progenitor is 0.7 $M_\odot$ higher.
Conclusions. Current constraints from observed Type II-P supernova light curves and pre-explosive luminosity do not exclude an ALP production within the current bounds. However, the maximum age of CCSN progenitors, as deduced from the star formation rate of the parent stellar population, would require a smaller minimum mass. This discrepancy can be explained by assuming a moderate extra mixing (as due to core overshooting or rotational induced mixing) above the fully convective core that develops during the main sequence.

Key words. stellar evolution – astroparticles - axions – supernovae – white dwarfs

1. Introduction

In this work we revise models of single stars with mass in the range $3 < M/M_\odot < 11$ taking into account the effects of a possible thermal production of axions or, more in general, axion-like-particles (ALPs). In a previous paper, we have discussed the impact of ALPs on the evolution of star with $M > 11\ M_\odot$ (Straniero et al. 2019), while the effect of a possible production of ALPs in intermediate-mass stars ($3 < M/M_\odot < 7$) has been illustrated in

This is the most common type of WDs. When they are part of a close binary, these WDs can accrete mass from a companion star and this accretion can trigger a variety of explosive phenomena, including: cataclysm variables, Novae and type Ia supernovae (SNIa). Therefore, the maximum mass of the COWD progenitors is a fundamental parameter in studies of population synthesis and galactic chemical evolution. After Becker & Iben (1979), it is often referred as M_{up}, but in this paper we prefer to use M^{max}_{COWD}. The reason is that beyond this threshold, stars form a sufficiently

We dedicate this General Meeting as Memorial Workshop for Inma

COSMIC WISPers NETWORK

~ 70 *proposers*

Currently > 480 participants!



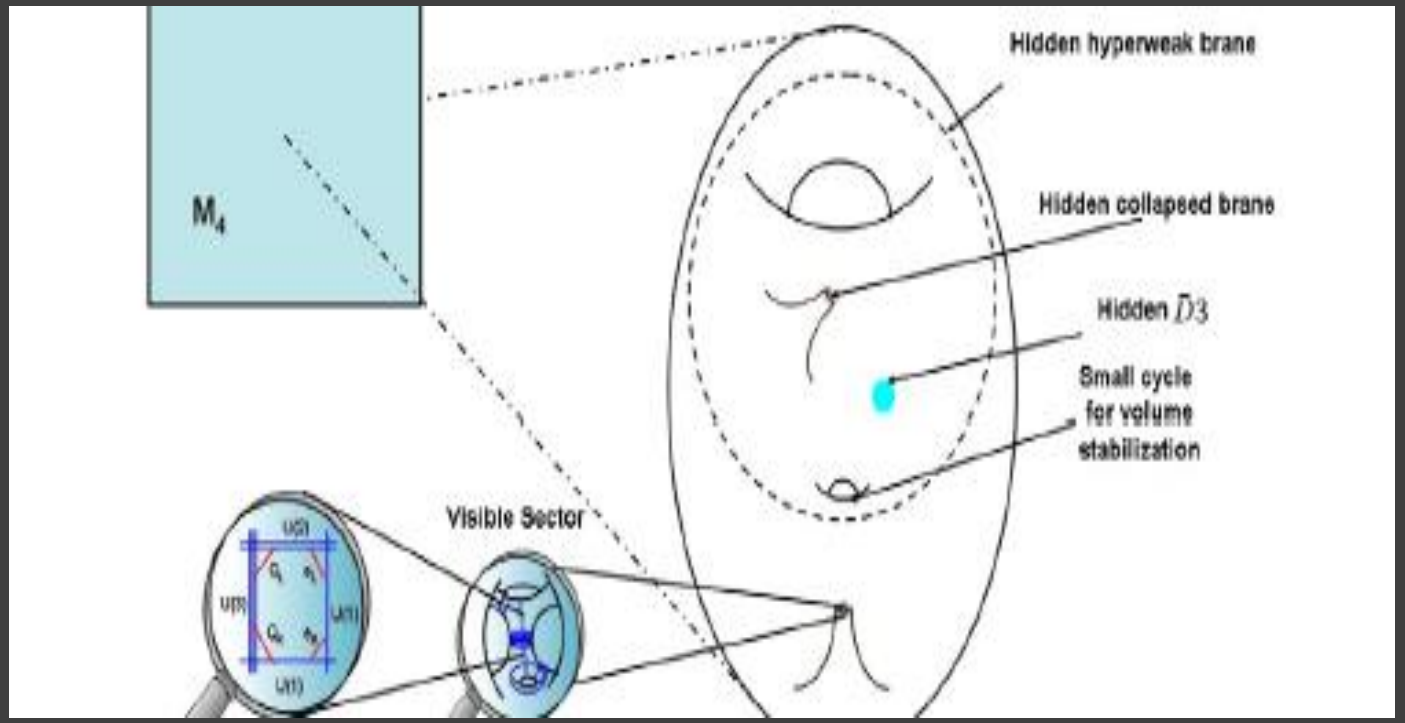


WISPs

WISPs are very Weakly Interacting Slim (m<GeV) Particles which emerge in several extensions of the Standard Model of Particle Physics.

CHALLENGE

The aim of this Action is an exhaustive study of these WISPs, notably axions, axion-like particles (ALPs) and dark photons, ranging from their theoretical underpinning, over their indirect observational consequences in astrophysics, to their search at colliders and beam-dump and their direct detection in laboratory experiments.



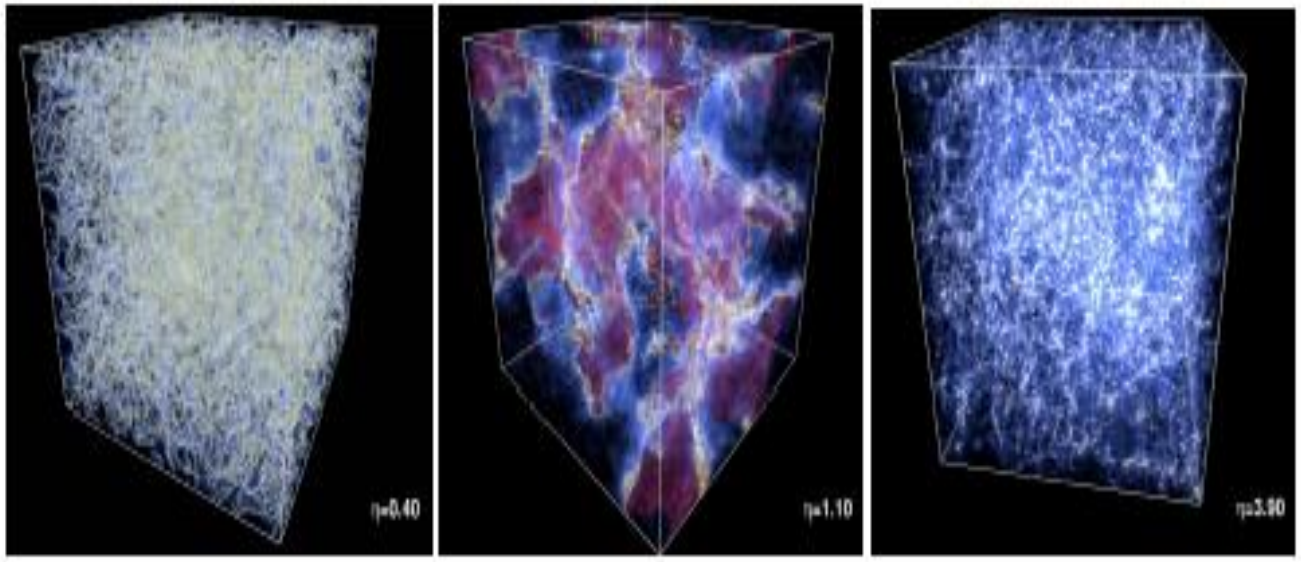
WG Leaders

Michele Cicoli (Bologna Univ., IT)
Nicole Righi (King's College, UK)
Arturo de Giorgi (Durham Univ., UK)

143 participants

WG1: THEORY AND MODEL BUILDING

Determine the nature, number, masses and couplings of WISPs that arise in well-motivated theories of fundamental physics, and in particular within string compactifications that join moduli stabilisation with (semi)-realistic matter sectors



WG Leaders

Edoardo Vitagliano (Padua Univ., IT)
Marco Gorghetto (DESY, DE)
Maria Benito Castano (Tartu Obs. EE)
Mathieu Kaltschmidt (Zaragoza Univ., ES)

289 participants

WG2: DARK MATTER AND COSMOLOGY

Obtain precise predictions of axion and WISP DM relic abundance and identify distinguishing features of WISP DM in Large Scale Structure data

WG3: WISPs IN ASTROPHYSICS

Deepen the studies of the signatures of WISPs in astroparticle physics. These include WISP oscillations into photons, WISP-induced energy loss in stellar systems and signatures from gravitational waves and from primordial black-hole superradiance.

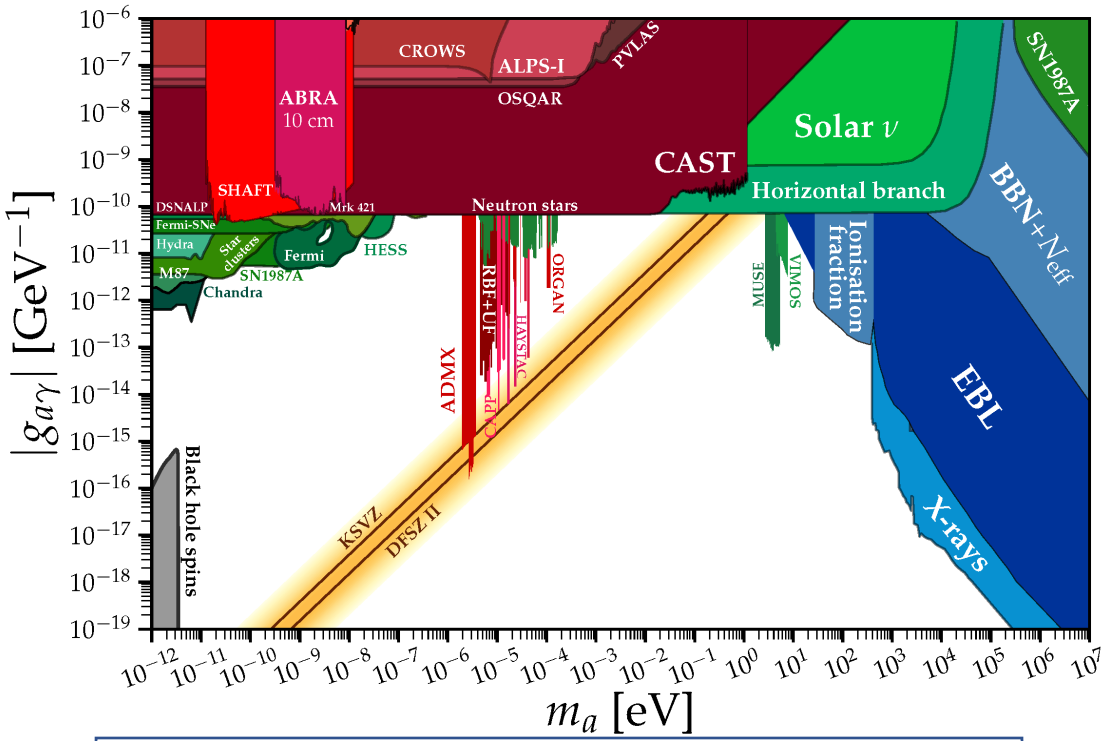
WG Leaders

Maurizio Giannotti (Zaragoza U., ES)
Oscar Straniero (INAF, IT)
Elisa Todarello (Nottingham Univ. UK)
Giuseppe Lucente (SLAC, USA)

173 participants

WG4: DIRECT WISPs SEARCHES

Produce a complete, updated and revised summary of the status of WISP searches, highlighting parts of the parameter space, models or couplings that are not under test by present or future searches. Outline a roadmap to WISP discovery and a way to disentangle among different WISP models



WG Leaders

Claudio Gatti (LNF, IT)
Marin Karuza (Rijeka Univ. , HR)
Deniz Aybas (Bilkent Univ. TR)

169 participants

WG5: DISSEMINATION AND OUTREACH

Enhance the dissemination and communication of the results, and to structure outreach activities to attract public awareness to the challenges and achievements in astro-particle physics.

WG Leaders

Olga Mena (IFIC, ES)

Science Communication Coordinator

Loredana Gastaldo (Heidelberg Univ , DE)

94 participants

DELIVERABLES (from MoU)

Deliverable number	Deliverable title	WG number	Deliverable date (months)
D1.1	Draft Report on theory and pheno	1	12
D1.2	Interim Report on theory and pheno	1	24
D1.3	Final Report on theory and pheno	1	48
D2.1	Draft Report on DM and cosmology	2	12
D2.2	Interim Report on DM and cosmology	2	24
D2.3	Final Report on DM and cosmology	2	48
D2.4	Public code to simulate axion effects on LSS	2	40
D3.1	Draft Report on astroph.	3	12
D3.2	Interim Report on astroph.	3	24
D3.3	Final Report on astroph.	3	48
D4.1	Draft Report on direct detection	4	12
D4.2	Interim Report on direct detection	4	24
D4.3	Final Report on direct detection	4	48
D4.4	Report on Technologies Forums	4	36
D5.1	Action webpage, twitter and repositories	5	6
D5.2	Set Dissemination and Communication Scheme	5	6, 18,30
D6.1	Lecture notes of the training schools	1,2,3,4	12,24,32,48
D7.1	Final White Paper on the Physics case	1,2,3,4	48

HORIZONTAL COMMITTEES

Grant Evaluation Committee: provides to the Action MC a proposal of selected grants and amounts for their approval
Grant Awarding Coordinator: **Venelin Kozhuharov** (Sofia Univ., BG)

Young Researchers and Innovators Representative Council: involve the ECI in the management of the Action and in organization of the Activities
Coordinator: **Marta Fuentes Zamoro** (Madrid Univ., ES)

Gender and Diversity Advisor: monitor the gender balance and provide a plan to implement gender balance
Deniz Sunar Cerci (Adiyaman Univ., TR)

- Journal Club Organizers: Silvana Abi Mershed (Bilkent Univ., TR), Xavier Ponce Diaz(Basel Univ. CH)

- Colloquium Organizers: Arturo de Giorgi (Inst. De Fis. Teor, ES), Giuseppe Lucente (Bari Univ., IT) , Hugo Tercas (Ist. de Plasma, Lisboa, PT)

- Newsletter Editors: Marta Fuentes Zamoro (Madrid Univ, ES), Mario Reig Lopez (Oxford Univ., UK)

All events announced on the webpage www.cosmicwispers.eu

CORE GROUP

The Action MC decided to delegate part of their power to a Core Group that may carry-on day by day management and urgency cases

The Core Group is constituted by Chair, Vice-Chair, WG Leaders, Grant Holder Scientific Repr., Science Comm. Coordinator, Grant Award. Coord., Young Researc. Council Repres., Gender Advisor

COST support beyond the COST Action

2025 EVENTS

13-14 Febr: Working Group Meeting (Heidelberg, DE)

16-19 September: Training School (Annecy, FR)

A quick look to the CA21106 General Meeting program

There will be plenary sessions and 4 parallel sessions corresponding to the different Working Groups:

- WG1: Theory and Model Building
- WG2: Dark Matter and Cosmology
- WG3: Astrophysics
- WG4: Direct Searches

- There will be also review on the WG activities by WG Leaders and round tables.
- On Thursday afternoon after the session there will be an outreach talk ….

All the contributions will be published on Proceedings of Science (PoS) edited by SISSA

PLEASE SIGN EVERY MORNING THE ATTENDANCE LIST

WELCOME IN SOFIA!