WG2 Discussion

1st General Meeting of COST Action COSMIC WISPers (CA21106),
Bari, Italy
September 8, 2023

Edoardo Vitagliano
edoardo.vitagliano@mail.huji.ac.il
Hebrew University of Jerusalem

האוניברסיטה העברית בירושלים
THE HEBREW UNIVERSITY OF JERUSALEM

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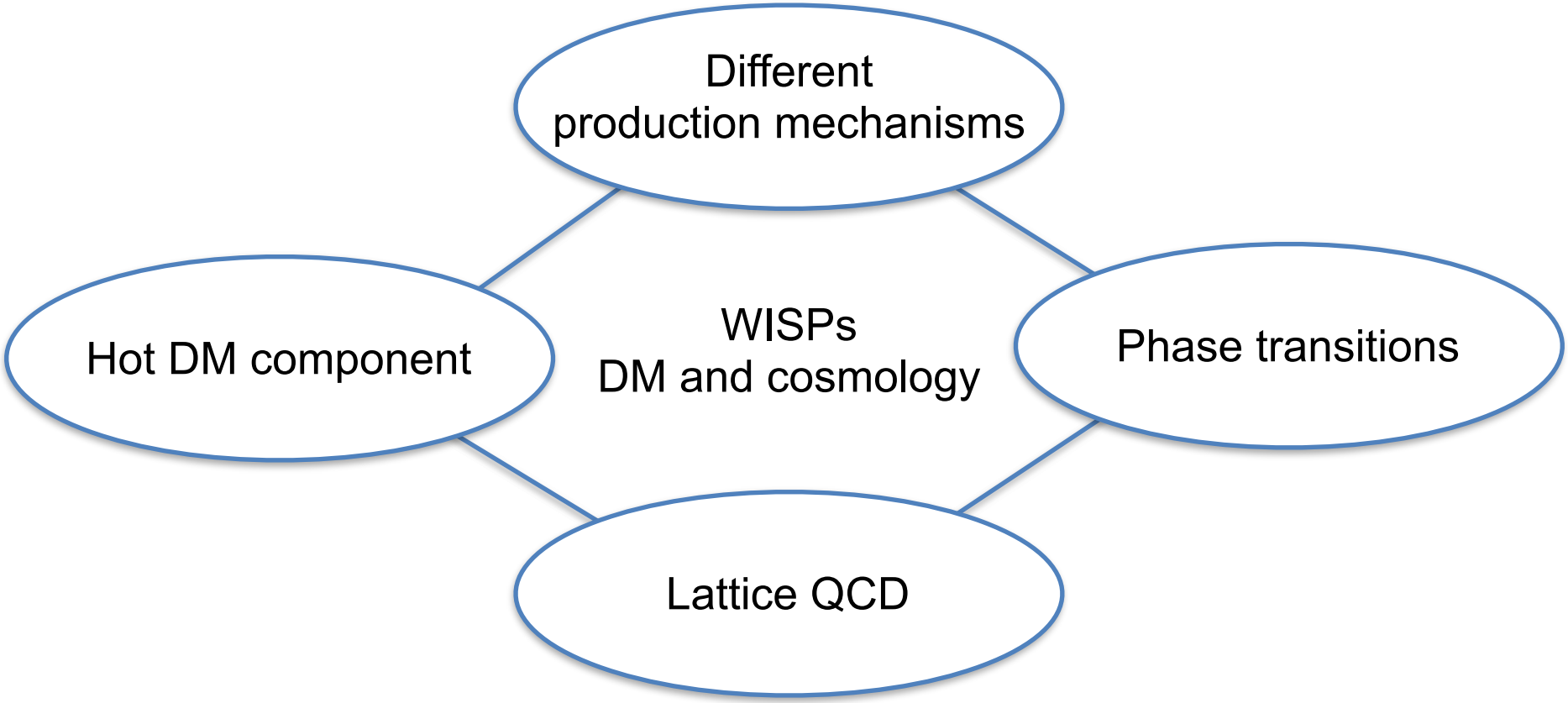
COSMIC WISPERS
CA21106

Working group 2 in a glance

Many questions:

- WISPs are a great DM candidate—how many ways to produce them?
- Different non-thermal processes, misalignment mechanism, phase transitions, topological defects networks
- If QCD axion is *the* DM, can we reliably predict its mass and couplings?
- What is the abundance of miniclusters? Huge consequences for WG3 and WG4

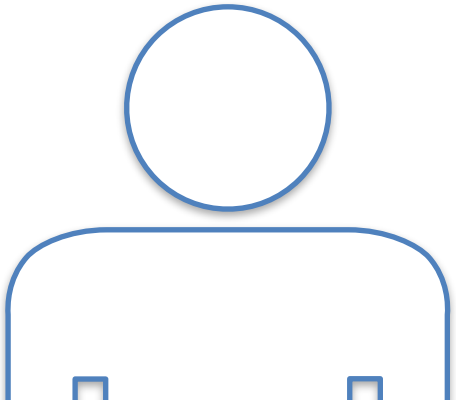
Working group 2 in a glance



A large community with many different expertises

- Around 150 people in the WG
- Great overlap with all the other WGs
- Several activities organized together with WG3

Coordinators



Edoardo Vitagliano

Javier Redondo

Important to get results

- Great experimental efforts to detect the QCD axion—extremely valuable to identify an expected mass range
- Very important consequences for large density variations
- Astrophysical signals might be very important to discover the nature of dark matter

Ongoing activities

Together with WG3, we have organized a timely online mini workshop on NANOGrav results

Wednesday, 5th of July

- 3pm Prof. Alberto Sesana, **Nano-Hz gravitational waves: first evidence and implications**

From 4pm on the same day

- Fabrizio Rompineve (CERN), **Footprints of the QCD Crossover on Cosmological Gravitational Waves at Pulsar Timing Arrays**
- Yann Gouttenoire (Tel Aviv University), **TBC**
- Marek Lewicki (University of Warsaw), **Cosmic Superstrings Revisited in Light of NANOGrav 15-Year Data**
- Antonio Iovino (La Sapienza University of Rome), **The recent gravitational wave observation by pulsar timing arrays and primordial black holes: the importance of non-gaussianities**
- Anish Goshal (University of Warsaw), **Probing the Dark Matter density with gravitational waves from super-massive binary black holes**

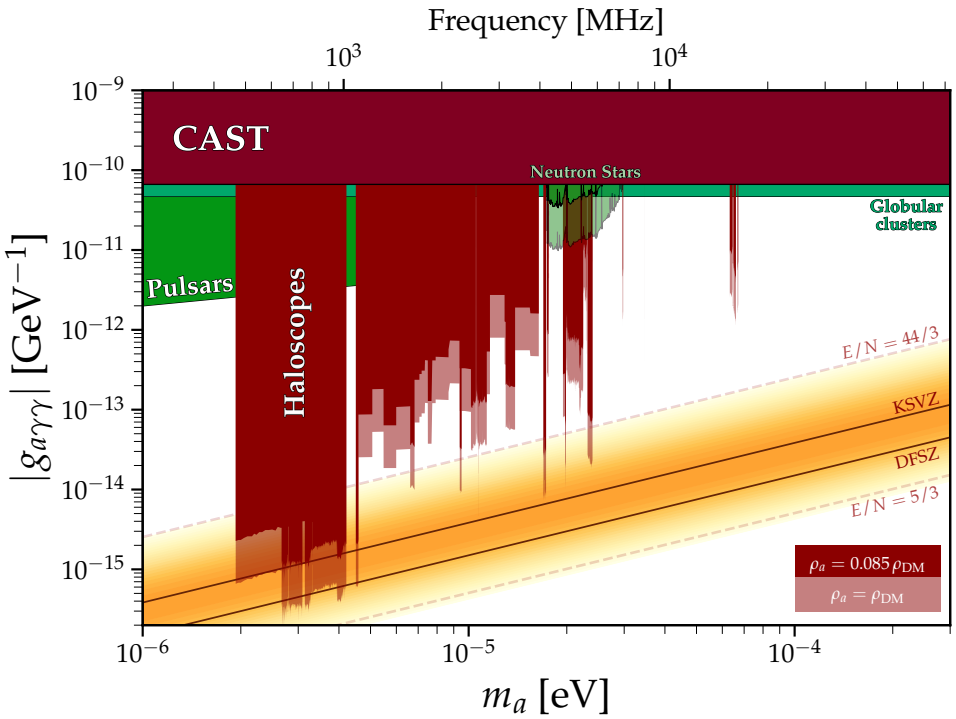
Planning ahead

- Possible workshops and schools dedicated to prediction of the DM abundances
- Possibility of funding visiting periods
- We plan to ask all the people in the working group to fill up a form with name, institution, reasons why they join the working group, and how they could contribute to the success in reaching the goals of the WG
- Continued collaboration with WG3 (planning a mini-workshop similar to the one dedicated to NANOGrav)
- Subtask 2.1.4 an important goal to be reached with the collaboration of the members
- Other subtasks could be realized as the result of collaborations inspired by the WG

This workshop

Ciaran O'Hare talk

Implications for haloscopes



Eggemeier, CAJO+ [2212.00560]

Typical density in the minivoids is ~0.085 of the mean density of dark matter

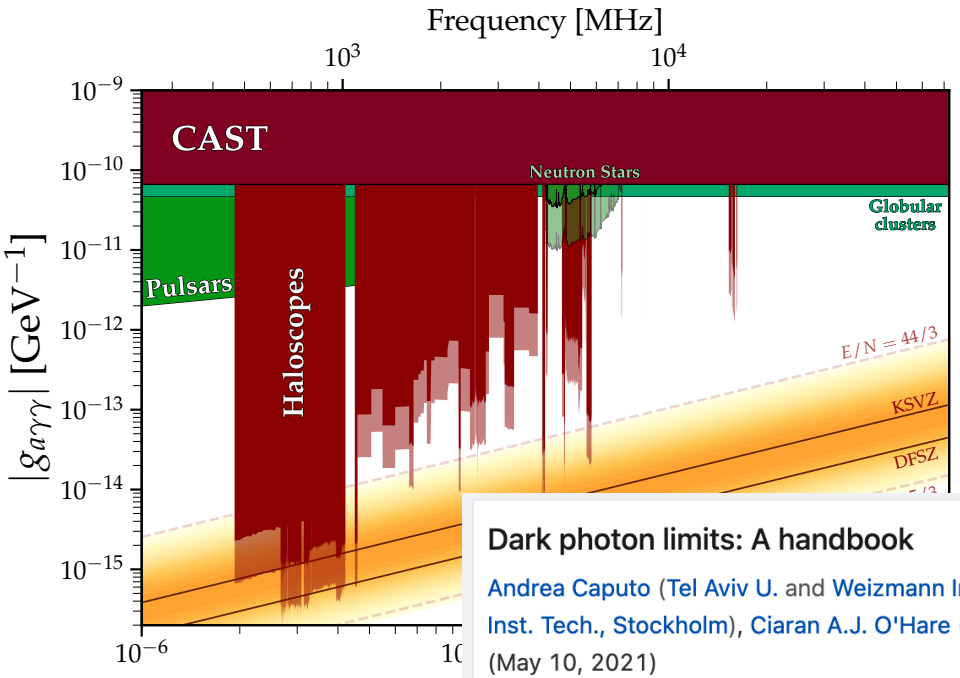
→ the miniclusters are no longer growing at the final redshift of the simulation, therefore this places a **lower bound** on the density of axions

→ Not a nice conclusion, but it could have been much worse!

This workshop

Ciaran O'Hare talk

Implications for haloscopes



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Dark photon limits: A handbook #4

Andrea Caputo (Tel Aviv U. and Weizmann Inst.), Alexander J. Millar (Stockholm U., OKC and Nordita and Royal Inst. Tech., Stockholm), Ciaran A.J. O'Hare (Australia, CSIRO, Sydney and Sydney U.), Edoardo Vitagliano (UCLA) (May 10, 2021)

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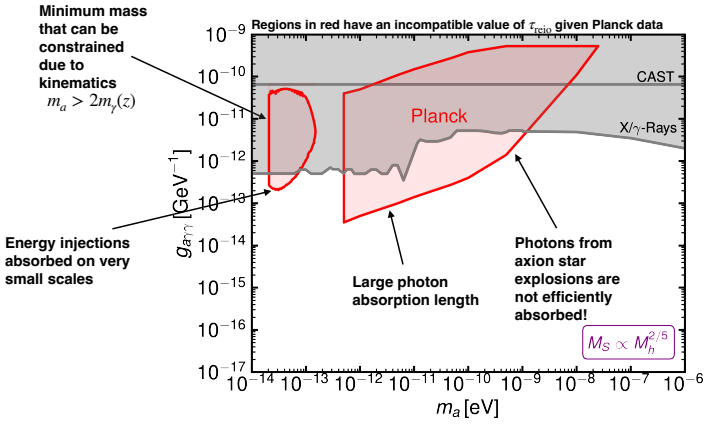
pdf links DOI cite claim reference search 125 citations

This workshop

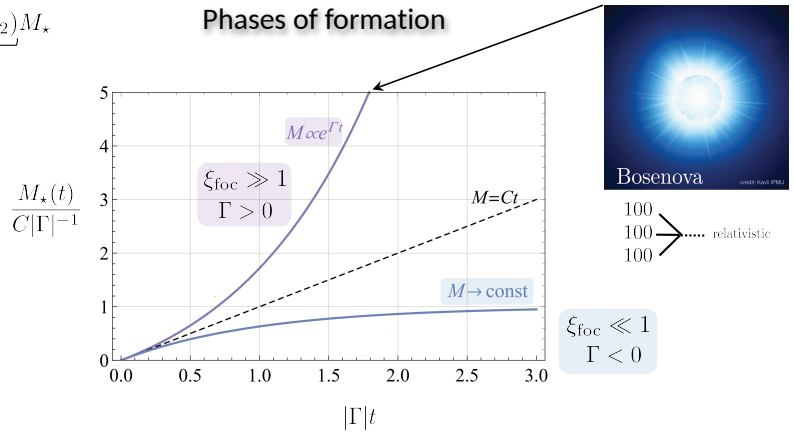
Miguel Escudero talk

Resulting Constraints



Marco Gorghetto talk

$$\dot{M}_\star = C + \underbrace{(\Gamma_1 - \Gamma_2)}_{\Gamma} M_\star$$



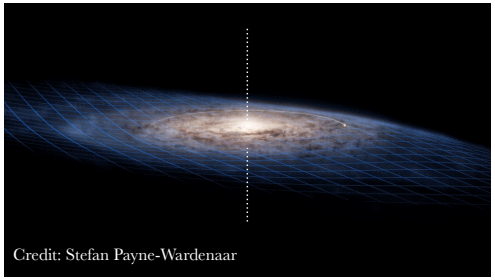
$$\rho_{\rm crit} \equiv \frac{2\Phi_{\rm ex} m^2}{|g|} \simeq 2\frac{\alpha^2 m^2}{|g|} \simeq 6 \cdot 10^4 \rho_{\rm dm} \left[\frac{f_a}{5 \cdot 10^7\,{\rm GeV}}\right]^2 \left[\frac{m}{1.7 \cdot 10^{-14}\,{\rm eV}}\right]^4 \left[\frac{M}{M_\odot}\right]^2 \left[\frac{0.4\,{\rm GeV/cm^3}}{\rho_{\rm dm}}\right]$$

This workshop

Maria Benito talk

Dark Matter distribution (under steady-state and axial symmetry)
accounting for uncertainties on:

1. *Rotation curve measurements*
2. *Morphology (3D shape) baryons*
3. *Normalisation (mass) baryons*
4. *Galactic parameters: Sun's velocity & Galactocentric distance*

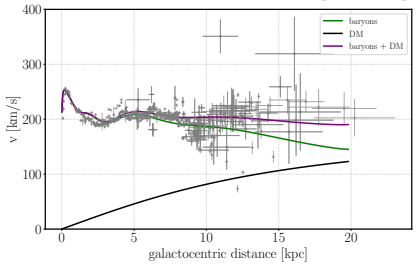


$$\chi^2_{\mathrm{RC,prof}}(V_0, R_s, \rho_0, \gamma)$$

Likelihood accounts for astro uncertainties & its available @
https://github.com/mariabenitocst/UncertaintiesDMinTheMW

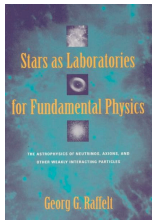
MB + [1901.02460] / MB + [2009.13523] / Põder, MB + '23 (accepted in A&A)

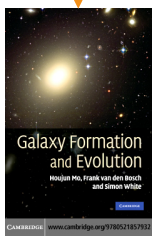
Sofue + [0811.0859]

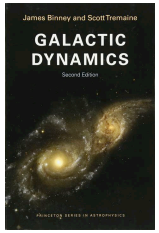


This workshop

Diego Blas talk







Conclusions

- Galactic dynamics is modified for "extreme" DM (e.g. ULDM or DDM)
  - many "classical aspects" modified (not fully explored!)
- ULDM: for $m \lesssim \mathrm{eV}$ occupation number of DM states in MW $O(1)$
  - wavy halo: coherent oscillating patches (modified heating, DF, grav scattering)
  - soliton: extra features at galactic centres. Can be probed with dynamics
- Degenerate DM: for $m \lesssim \mathrm{keV}$ occupation number of DM states in dSph $O(1)$. Fermionic DM will be close to degeneracy
  - degeneracy pressure: presence of core.
  - filled Fermi surface: gravitational scattering modified (DF, heating…)

This workshop

WG1: Which particle models are interesting?

WG2: Computing the abundance, large overlaps with numerical simulation communities

WG3: Effects on astrophysical bounds!

WG4: Effects on laboratory searches!

WG5: Nice plots and visualizations, good help for outreach