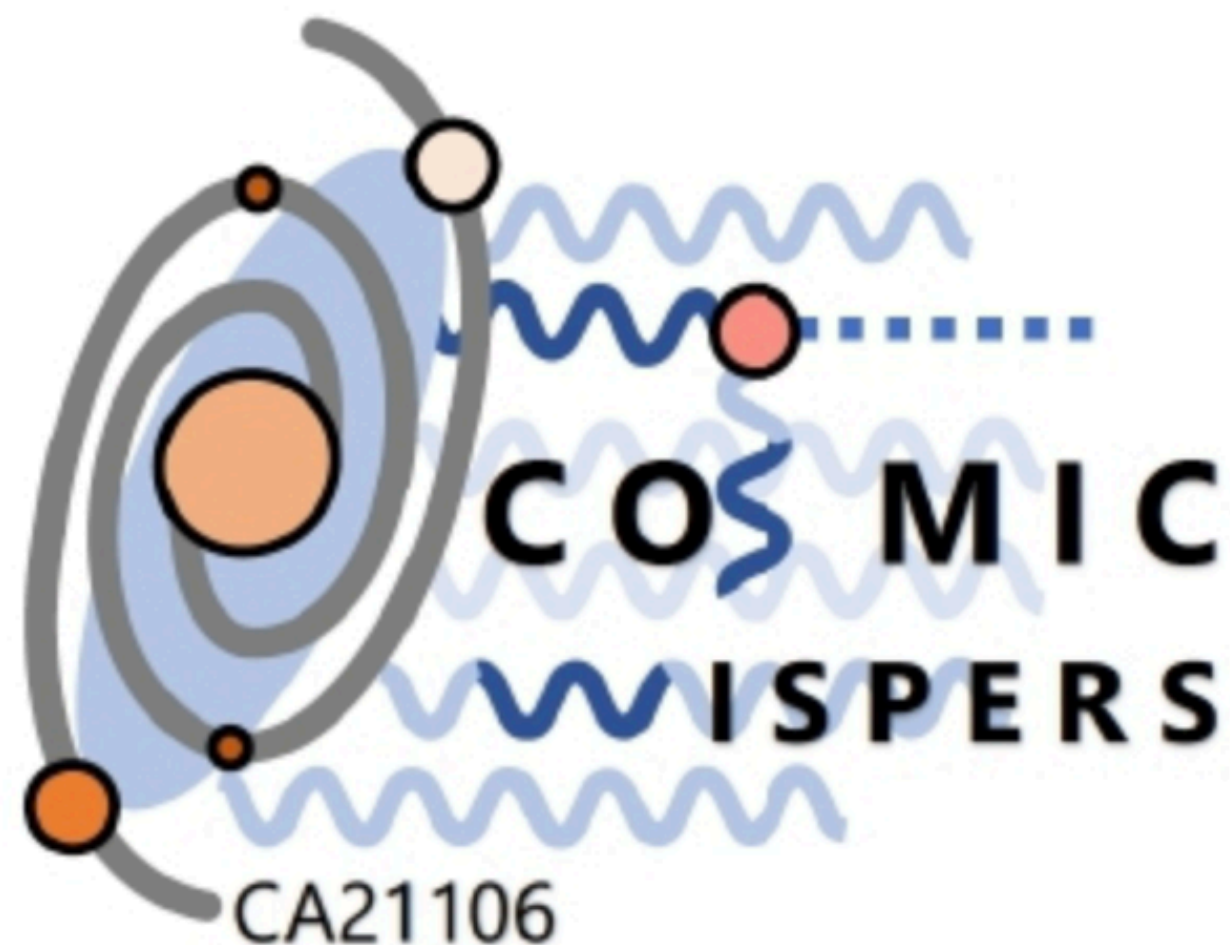


# WG3: WISPs IN ASTROPHYSICS

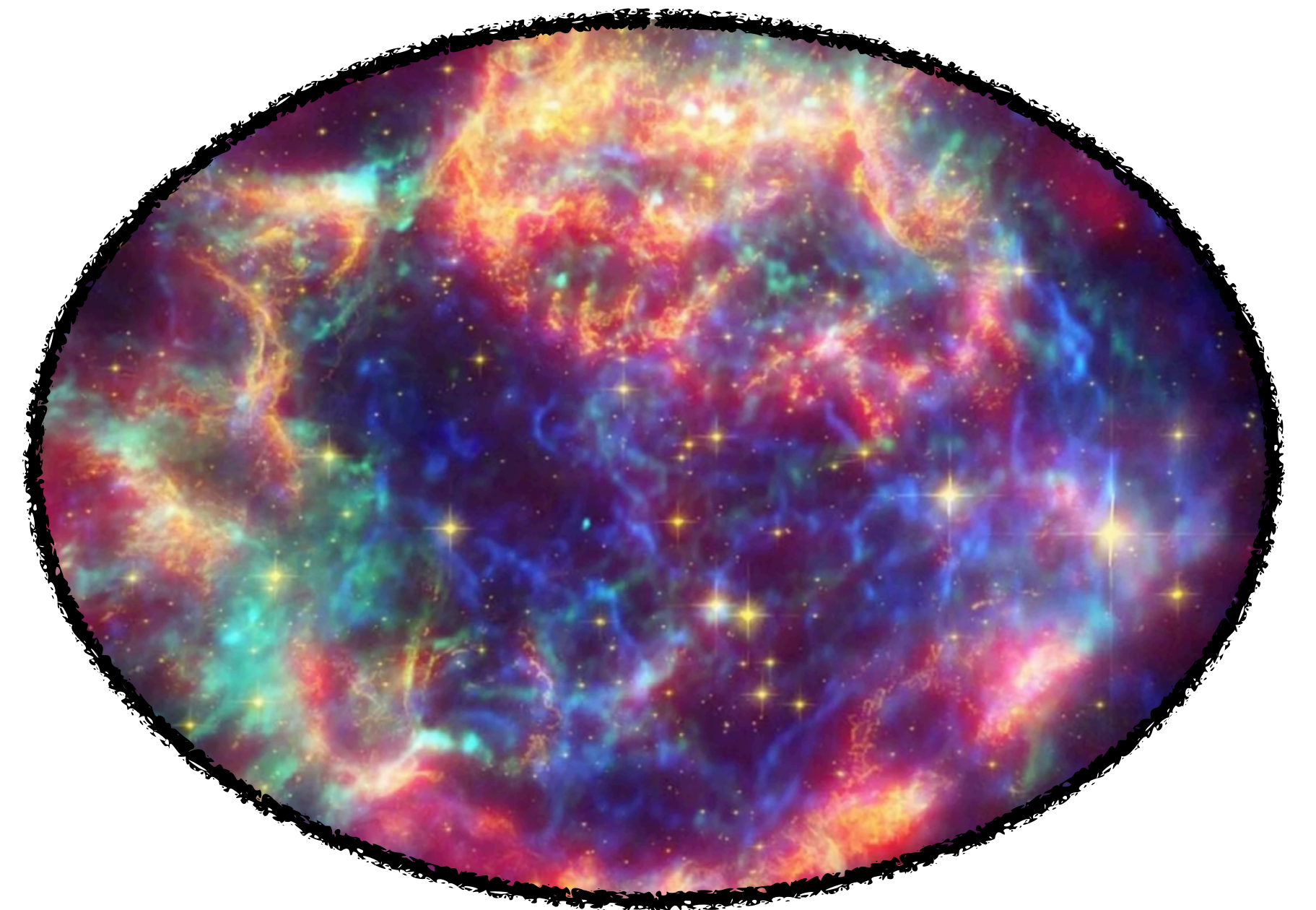
ANDREA CAPUTO  
(CERN)

First Workshop COST ACTION COSMIC WISPers (CA21106)  
Bari, 05-09 2023



# General mission and interests of WG3

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



# WG3 Organization and numbers

WG3 Leader: Andrea Caputo, [andrea.caputo@cern.ch](mailto:andrea.caputo@cern.ch)  
WG3 Co-Leader: Oscar Straniero, [oscar.straniero@inaf.it](mailto:oscar.straniero@inaf.it)

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Name	Working Group	Country
Prof Joseph CONLON 	WG 1, WG 3	United Kingdom
Dr Marco CHIANESE 	WG 1, WG 3, WG 5	Italy
Mr Arturo DE GIORGI 	WG 1, WG 3	Spain
Dr Gaia LANFRANCHI 	WG 1, WG 2, WG 3, WG 4	Italy
Prof Alessandro MIRIZZI 	WG 2, WG 3, WG 5	Italy
Dr Andrea CAPUTO 	WG 2, WG 3	Israel
Dr Christoph WENIGER 	WG 2, WG 3	Netherlands
Mr Christopher ECKNER 	WG 2, WG 3	France
Dr Daniele MONTANINO 	WG 2, WG 3	Italy
Dr Edoardo VITAGLIANO 	WG 2, WG 3, WG 5	Israel

**149!** people already registered and present on the website, but we continue to get more applications!

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WG3 Co-Leader: Oscar Straniero, [oscar.straniero@inaf.it](mailto:oscar.straniero@inaf.it)

**Large overlap with WG2, Dark Matter and Cosmology**

WG2 Leader: Edoardo Vitagliano, [edoardo.vitagliano@mail.huji.ac.il](mailto:edoardo.vitagliano@mail.huji.ac.il)  
WG2 Co-Leader: Javier Redondo, [jredondo@unizar.es](mailto:jredondo@unizar.es)

# Resume of past Activities



## First, a reminder from the MoU main objective:

Primary objective: ``organize the scientific foundation for the next generation of WISPs experiments and searches, and to **promote a roadmap for the researchers**, research sponsors and the **broader scientific community**''

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- Organization of Short Term Scientific Missions (STSM);



Already few STSM missions funded!

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Dear all,

given the (justified) excitement about the GW detection, we decided to double our events! So now next Wednesday we will start at 3pm with Prof. Alberto Sesana introducing PTA and SMBHs, and then we will pass to a series of small talks (~ 12m each) about consequences of the detection. In particular we are extremely happy to have Fabrizio Rompineve, Yann Gouttenoire, Marek Lewicki, Antonio Junior Iovino and Anish Ghoshal.

So, that's the complete plan!

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 Ghoshal (University of Warsaw), **Probing the Dark Matter density with gravitational waves from super-massive binary black holes**

See you all at this Zoom address on that very day! <https://cern.zoom.us/j/66024461469?pwd=QzBhemdRZVlmNitKemNLR1V3eXNsUT09>

Best,

Andrea

Organised together with WG2!

In line with the MoU objective "Coordinate and support in a synergic way WISPs searches carried on **by the different WGs**, in order to stimulate and consolidate collaborations"

**200 participants!** Event about the recent Nanograv GW discovery

The screenshot shows a Zoom meeting slide with the following content:

- Population parameters**
  - 1-Galaxy merger rate  $\longleftrightarrow$  MBHB merger rate affects the number of sources at each frequency  $\rightarrow N_0$
  - 2-MBH mass - merging galaxy relation affects the mass of the sources  $\rightarrow M_c$
- Local dynamics**
  - 1-Accretion (when? how?) affects the mass of the sources  $\rightarrow M_c$
  - 2-MBHB - environment coupling (gas & stars) affects the chirping rate of the binaries  $\rightarrow \gamma$  affects the eccentricity  $\rightarrow$  chirping rate  $\rightarrow \gamma$  & single source detection

The slide also features a mathematical equation for the gravitational wave strain  $h_c^2(f)$  and a power-law relationship  $h_c(f) \propto n_0^{1/2} f^{-\gamma} M_c^{5/6}$ . Hand-drawn yellow and green circles highlight specific terms in the equation and the power-law relation. Two diagrams on the right show trajectories in a 2D plane, one with a red arrow pointing towards a blue line and another with a red arrow pointing away from it.

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- Organization of Short Term Scientific Missions (STSM);
- We also organised online meetings and seminars
- Contribution to the COST-Action school (next week!)

Topics and Lecturers

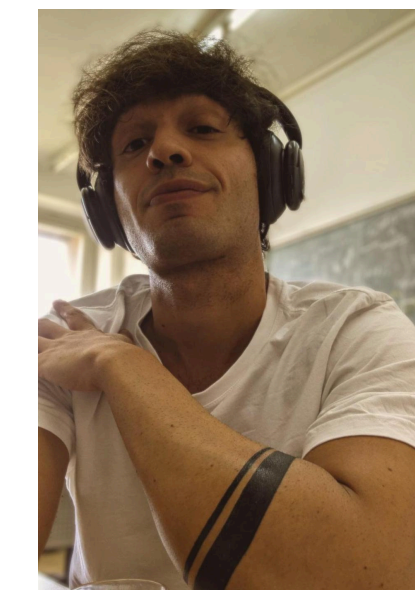
*"Axion theory and production in the early universe"*. Lecturer: Kiwoon Choi (IBS, Daejeon). Trainer: Nicole Righi (King's College, London)

*"Axion cosmology and cosmo bounds"*. Lecturer: Ciaran O'Hare (Sidney Univ.). Trainer: Mathieu Kaltschmidt (Zaragoza Univ.)

*"WISPs from stars"*. Lecturer: Georg Raffelt (MPI, Munich). Trainer: Andrea Caputo (CERN)

*"Axion experiments"*. Lecturer: Giuseppe Ruoso (INFN, Padua). Trainer: Antonios Gardikiotis (Patras Univ.)

*"Topics in science communication"*. Lecturer: Giuliana Galati (Bari Univ.)



Objective: "Attract young talented researchers from all over the world towards the activities of the Action through training activities"

**Planning ahead**

- Organization of dedicated seminars on specific topics, intended to be more “on-hands”, very practical talks.

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**Ex.** Seminar on the use of MESA for BSM physics (Speakers may include Jeremy Sakstein or Maurizio Giannotti)

We welcome suggestions and ideas, write to us!



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- Creation of a useful data repository (this is one of the important **deliverables!**)

Objective: “Develop a common database on WISPs theoretical models, experimental and astrophysical bounds”

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**Supernova Models**  
**White Dwarfs, Red Giants profiles**  
**Galactic and Extragalactic magnetic field configurations**  
**Axions, Dark Photons, Scalars emission rates**  
**Etc, etc.**

- Organization of dedicated seminars on specific topics, intended to be more “on-hands”, very practical talks.

Ex. Seminar on the use of MESA for BSM physics (Speakers may include Jeremy Sakstein or Maurizio Giannotti)

- Creation of important c

Ex. These nice Github repositories by S. Hoof and C. O’Hare, members of the Action!

### Solar Axion Flux

A C++ library to calculate the expected flux from axion-photon and axion-nucleon interactions from the Sun.

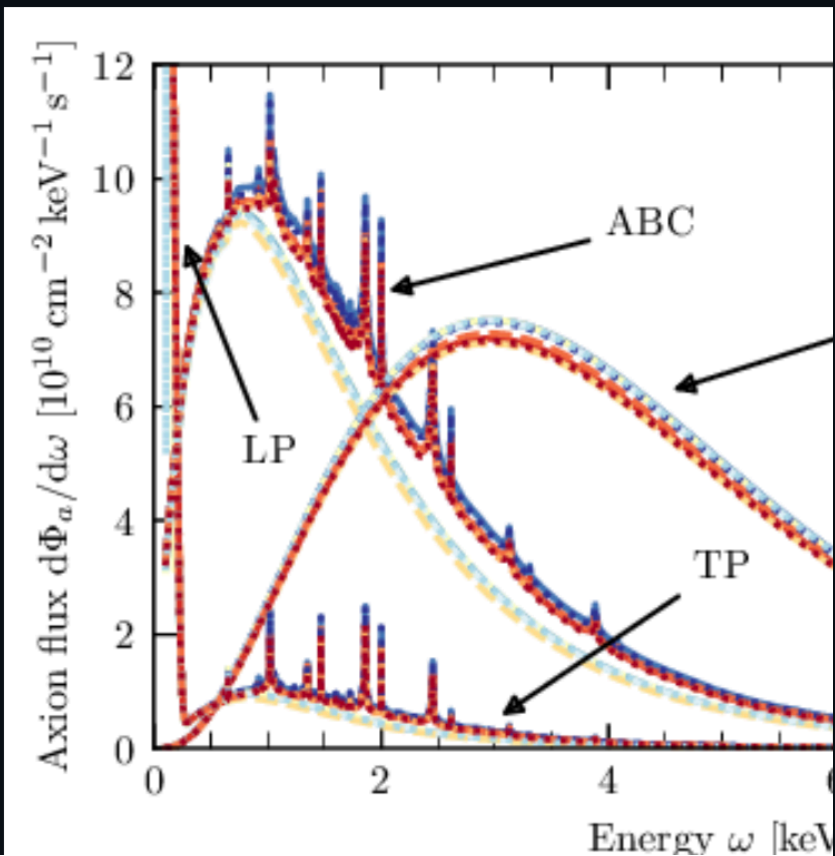
Developers: [Sebastian Hoof](#) and [Lennert Thormaehlen](#)

Information on how to acknowledge this work in the literature can be found [here](#).

This code has been published under the BSD 3-clause license. Contributions are welcome.

#### Example results

We use the code for our study on “Quantifying uncertainties in the solar axion model parameters.” The published paper can be found at [JCAP](#). Calculations of the axion flux from nuclear transitions were added last year and are available on the arXiv [arXiv:2111.06407](#).



### Axion-photon coupling

Basic plot

[View Notebook \(.ipynb\)](#)

[Download \(.pdf\)](#)

[Download \(.png\)](#)

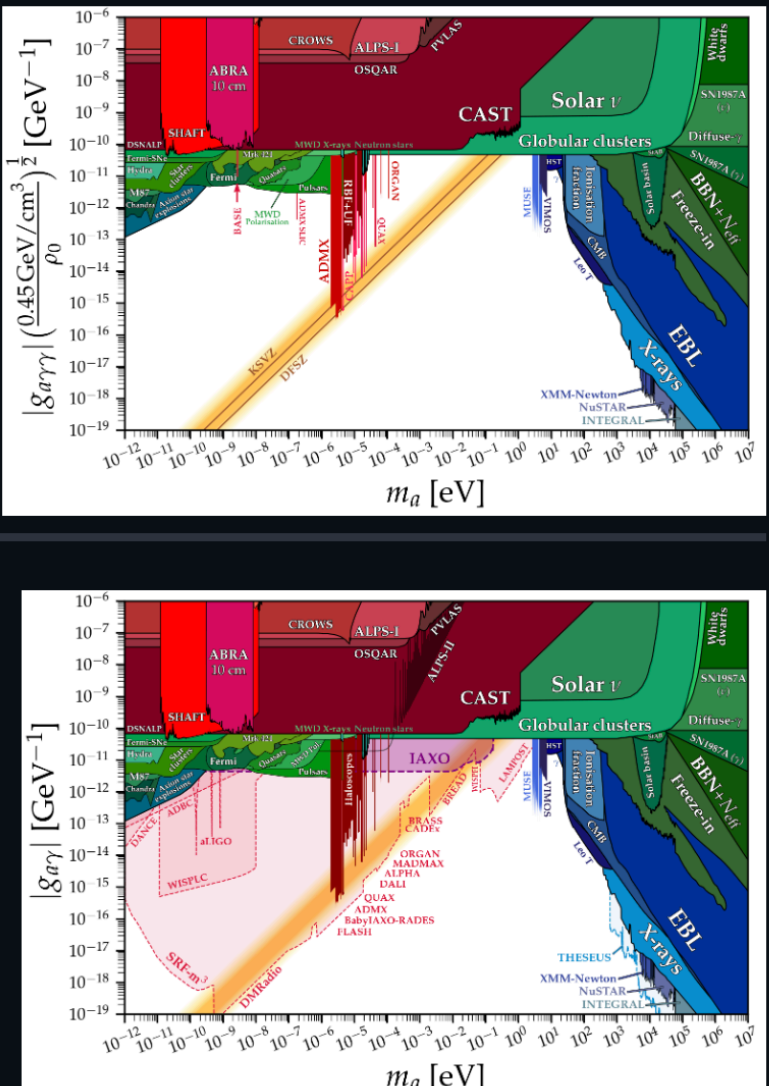
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Basic plot with projections

[View Notebook \(.ipynb\)](#)

[Download \(.pdf\)](#)

[Download \(.png\)](#)



- Organization of dedicated seminars on specific topics, intended to be more “on-hands”, very practical talks.

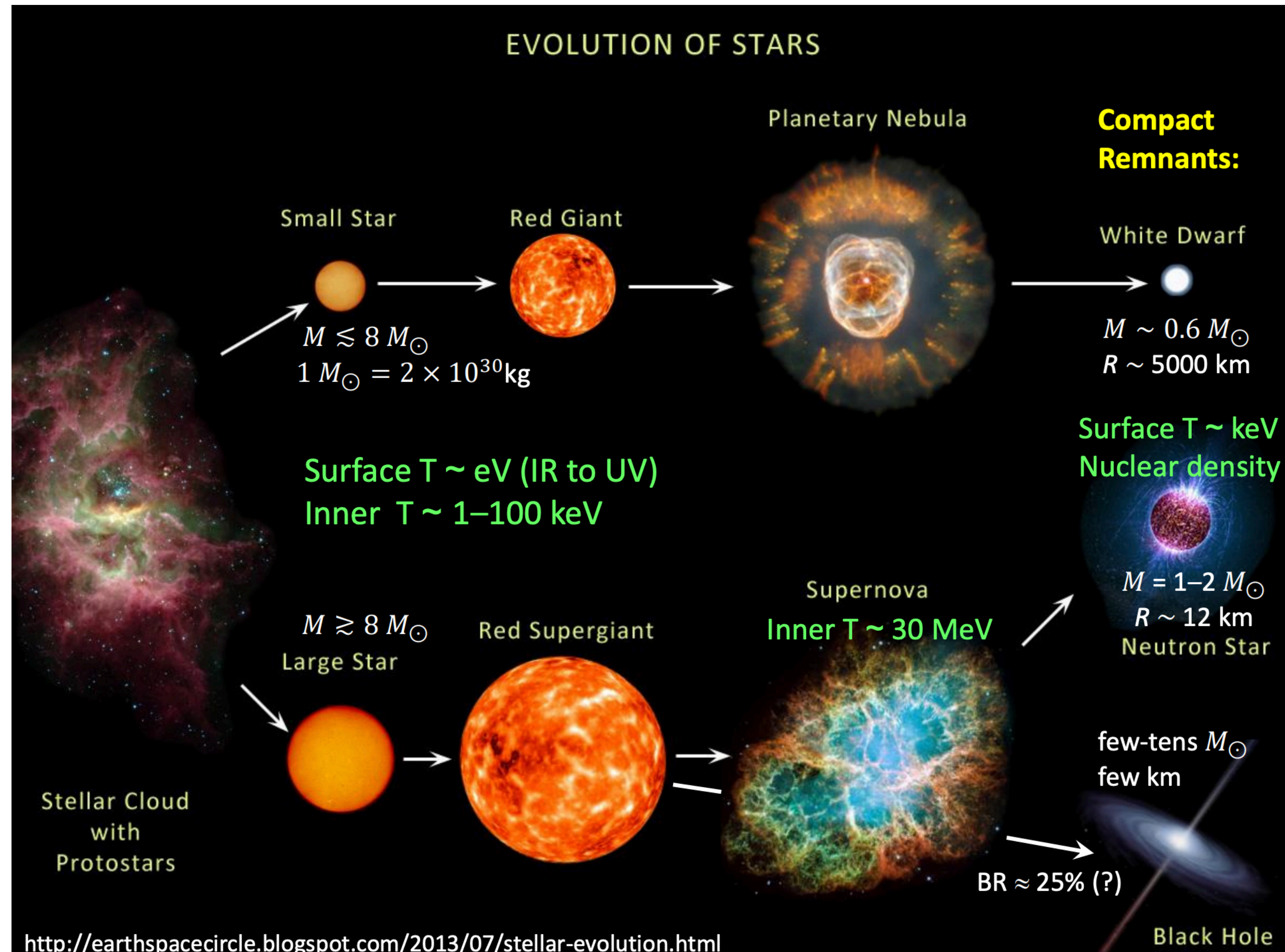
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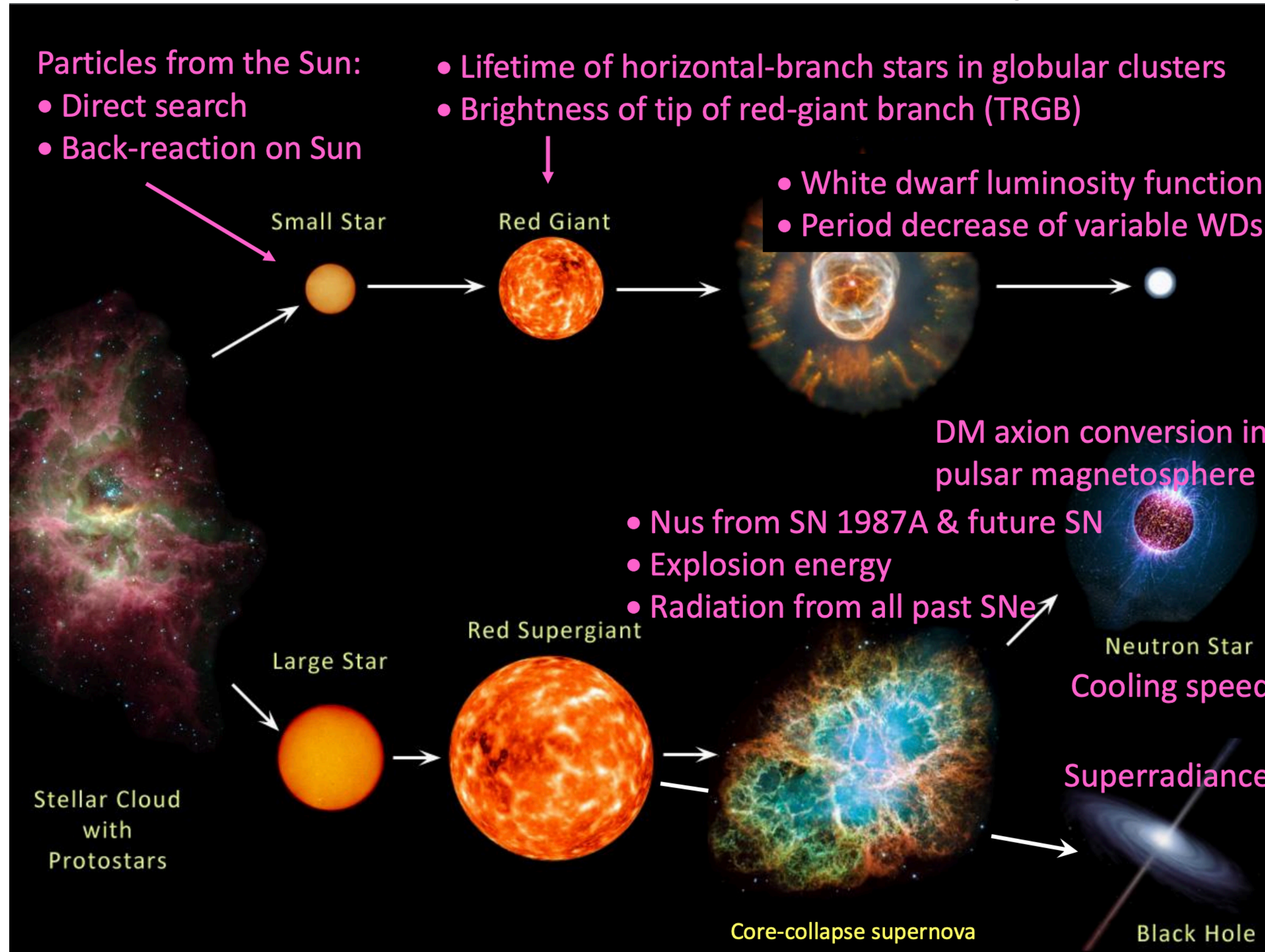
- Creation of a useful data repository (this is one of the important **deliverables!**)
- Organization for next year of **topical** mini-schools or workshop (in collaboration with WG2)

**Ex.** Mini-school for the use of MESA and/or SN models (at least in their simplified 1D realisations) for BSM physics

# Some physics

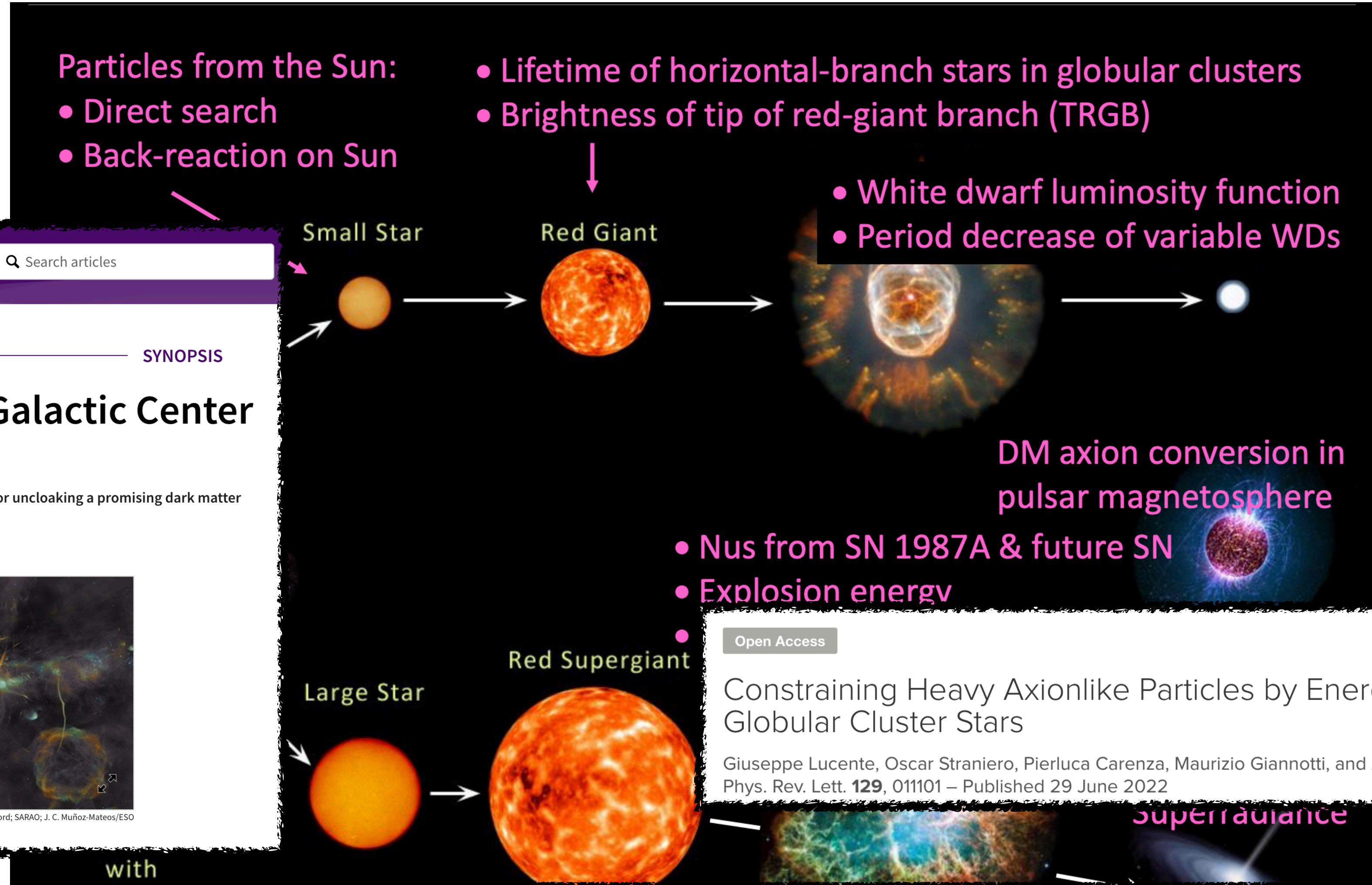
(Sorry, I love doing physics, couldn't help to put some)





# We get published in the best journals of the field!

Credit to Georg Raffelt, DESY Colloquium 2022



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SYNOPSIS

## Hunting for Axions in the Galactic Center

December 13, 2022 • Physics 15, s163

A neutron star's ultrastrong magnetic field could create the conditions for unclocking a promising dark matter candidate.

I. Heywood/University of Oxford; SARAO; J. C. Muñoz-Mateos/ESO

Sam Witte and collaborators

with Protostars

Open Access

### Constraining Heavy Axionlike Particles by Energy Deposition in Globular Cluster Stars

Giuseppe Lucente, Oscar Straniero, Pierluca Carenza, Maurizio Giannotti, and Alessandro Mirizzi  
Phys. Rev. Lett. **129**, 011101 – Published 29 June 2022

### Low-Energy Supernovae Severely Constrain Radiative Particle Decays

Andrea Caputo, Hans-Thomas Janka, Georg Raffelt, and Edoardo Vitagliano  
Phys. Rev. Lett. **128**, 221103 – Published 3 June 2022



# What can we expect?

- Search for solar axions
- Extension & refinements of existing arguments
- Search for magnetically converted ALPs
- Radio search for axion dark matter conversion in neutron star magnetospheres
- Next galactic supernova observation
- Gravitational-wave evidence for superradiance from black holes

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- Next galactic supernova observation
- Gravitational-wave evidence for superradiance from black holes
- New, out of the box ideas

# Thank you for the attention

