

Executive summary of the virtual YOUNGST@RS MIT Event

Feebly Interacting Sectors Impact on Cosmology & Astrophysics

FISICA 2022

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Some of the most urgent questions in the field in particle physics are more open than ever. Turning our gaze to the sky we can see how astrophysical objects and transient effects can shed light on open questions in fundamental physics and open new avenues.

Different types of stars—such as horizontal branch stars, the sun, supernovae (SNe), neutron stars, black holes—offer different guises to explore fundamental physics, and in particular physics beyond the standard model.

For example, the emission of weakly interacting particles causes a direct energy-loss channel from the interior of stars. If a new particle were to exist, stars may lose energy faster and therefore observed stellar properties are able to put tight constraints on well motivated particles such as the QCD axion (introduced to explain the strong CP problem) or the dark photon, a putative gauge boson routinely advocated to explain different standard model puzzles.

New particles produced in stars, or dark matter surrounding them, can also generate visible light signals in the X-ray or gamma-ray bands. This is possible if the new degrees of freedom are allowed to decay to (or oscillate to) ordinary photons.

As a matter of fact, the most stringent constraints in large portions of parameter space of many motivated new particles already come from stars.

Furthermore, the emission of new particles can even alter dramatically the evolution of more massive stars and therefore influence black hole mass distributions, a crucial target for all operating gravitational waves which are continuing to accumulate events and statistics.

The four-days virtual workshop FISICA 2022 brought together the particle physics, astrophysics and astronomy communities, forging new collaborations that will help refine existing ideas, identify the most promising candidate theories and come up with new possible signatures from astrophysical objects. The key focus were on stellar and Supernovae signatures, x-ray observations, direct detection of feebly interacting particles, and dark matter interactions in astrophysical environments.

The workshop involved 12 talks and 10 short talks. Three talks per day have been of 40 minutes each plus 5 minutes for discussion, while the short talks consisted of 15 minutes talk with 5 minutes for discussion. The session had 30 minutes of discussion between them. Compared to many workshops, the number of talks per day has been small in order to foster stimulating discussions.

The **first day** was dedicated in particular to the lessons we learn from astrophysical objects such as Supernovae and Red Giants. The opening talk was given by Georg Raffelt (MPP in Munich), followed by the talk by Irene Tamborra (Bohr Institute) and Oscar Straniero (INAF). After the coffee break we instead had three talks by Manibrata Sen (Heidelberg University), Emanuele Greco (University of Palermo).

The **second day** was focused on extreme astrophysical environments, such as pulsars magnetospheres. The first talk of the day was delivered by Francesca Calore (Annecy Lab), followed by Sasha Philippov (CCA) and Malte Buschmann (Princeton University). We then had two short talks on this day, delivered by Sam Witte (GRAPPA Institute) and Josh Foster (MIT).

The **third day** was dedicated to direct searches for dark sectors. The first talk was given by Igor Irastorza (University of Saragoza), the second one by Ken Van Tilburg (NYU) and the third one by Asimina Arvanitaki (Perimeter Institute). The short talks were instead given by Alex Millar (Stockholm University), Chiara Salemi (MIT) and Will De Rocco (UC Santa Cruz).

The **fourth and last day** of the Workshop was dedicated to alternative probes of dark sectors such as gravitational waves, gamma-ray searches from celestial bodies, etc. The opening talk was given by Djuna Croon (Durham University), followed by Joachim Kopp (CERN and University of Mainz) and Rebecca Leane (SLAC). The last two short talks of the workshop were delivered by Volodymyr Takhistov (IPMU) and Hannah Banks (Cambridge University).

Our goal has been to organize a workshop strongly promoting equal opportunities and gender balance. We believe that the virtual YOUNGST@RS MITP event *Feebly Interacting Sectors Impact on Cosmology & Astrophysics* was very successful in bringing together experts from various universities all over the world, and in offering a valuable opportunity to both junior and senior researchers to learn and discuss about frontier topics of astroparticle physics.