Astrophysical and Terrestrial Signals of Axion Stars

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Basic Introduction

$$10^{-22}\,\mathrm{eV} \lesssim m_\phi \lesssim \mathrm{eV}$$

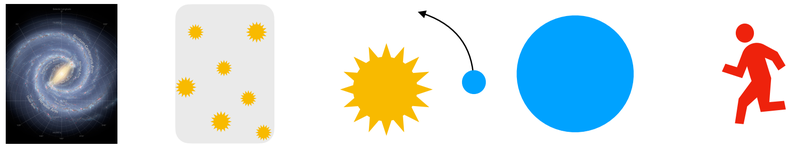
DM mass

Ultralight Dark Matter

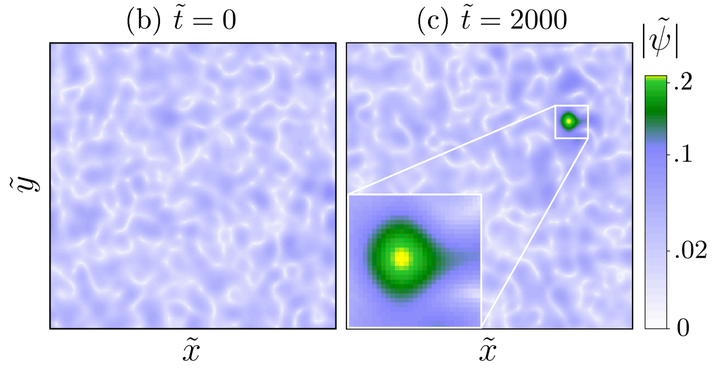
1. Ultralight particles predicted in many models of physics beyond the Standard Model
2. Can solve other puzzles in Standard Model (e.g. Strong CP or Hierarchy Problems)
3. Rich phenomenology, with detectable experimental signals for the coming decade

Ultrasmall Scales

$$\mathrm{kiloparsec} \lesssim \lambda_{\mathrm{dB}} \equiv 2\pi/m_\phi v \lesssim \mathrm{meter}$$



Levkov, Panin, Tkachev,
Phys. Rev. Lett. 121, 151301 (2018)



Relaxation of classical waves

↓

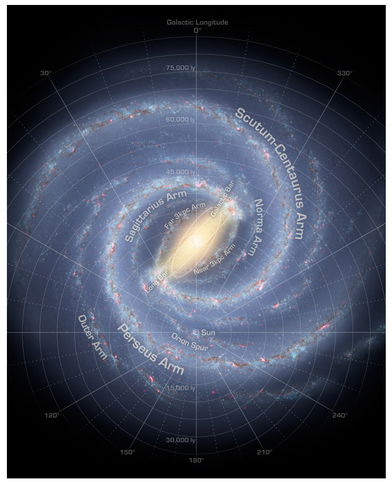
Formation of ***axion stars***

What is an Axion Star?

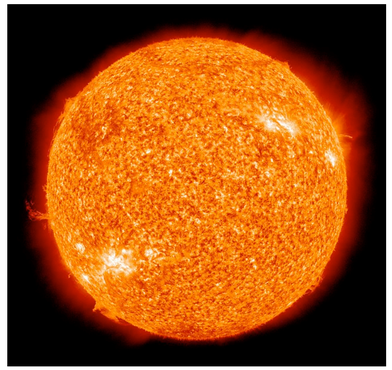
An **axion star** is an astrophysically large bound state formed from ULDM particles

Their typical mass $M_\star \propto m_\phi^{-2}$

galaxy

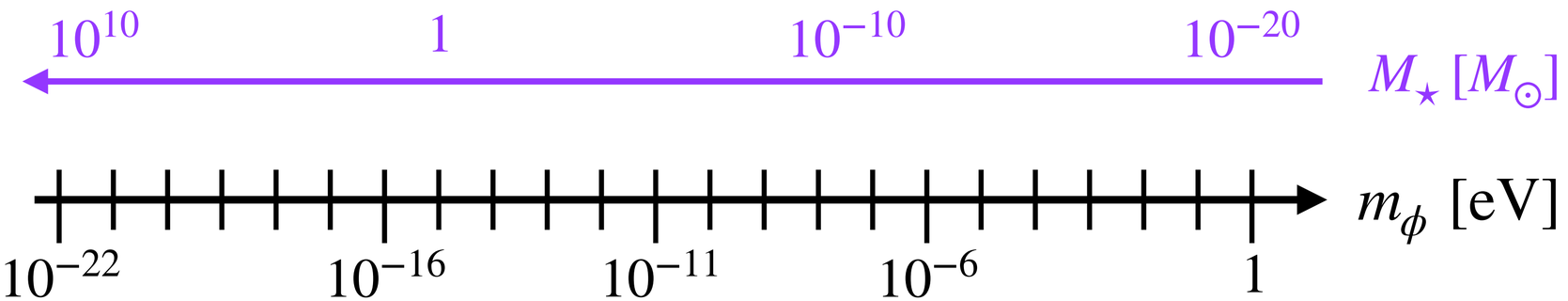


Sun



moon

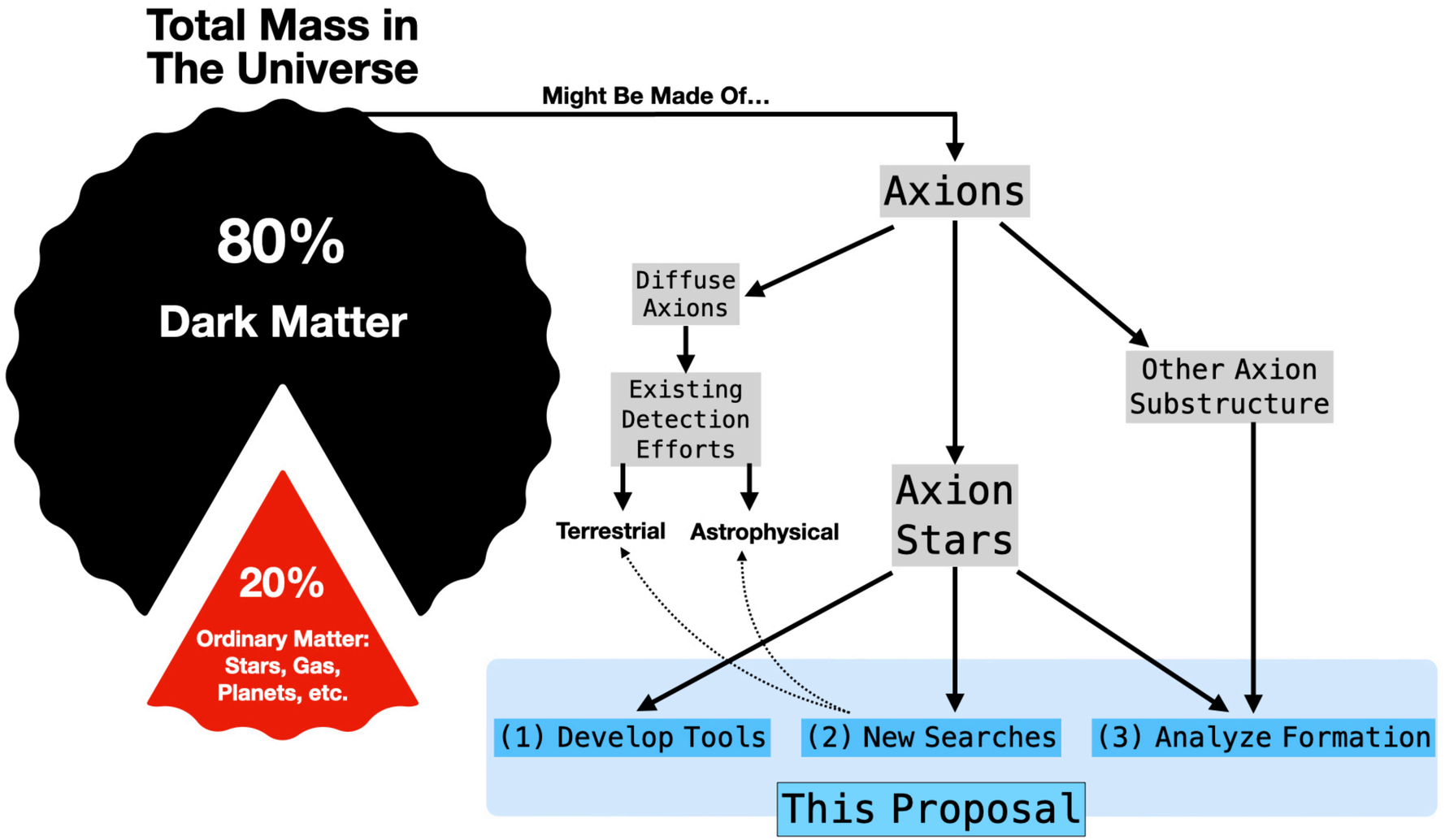
asteroid



Kaup 1968
Ruffini and Bonazzola 1969
Colpi, Shapiro, Wasserman 1986

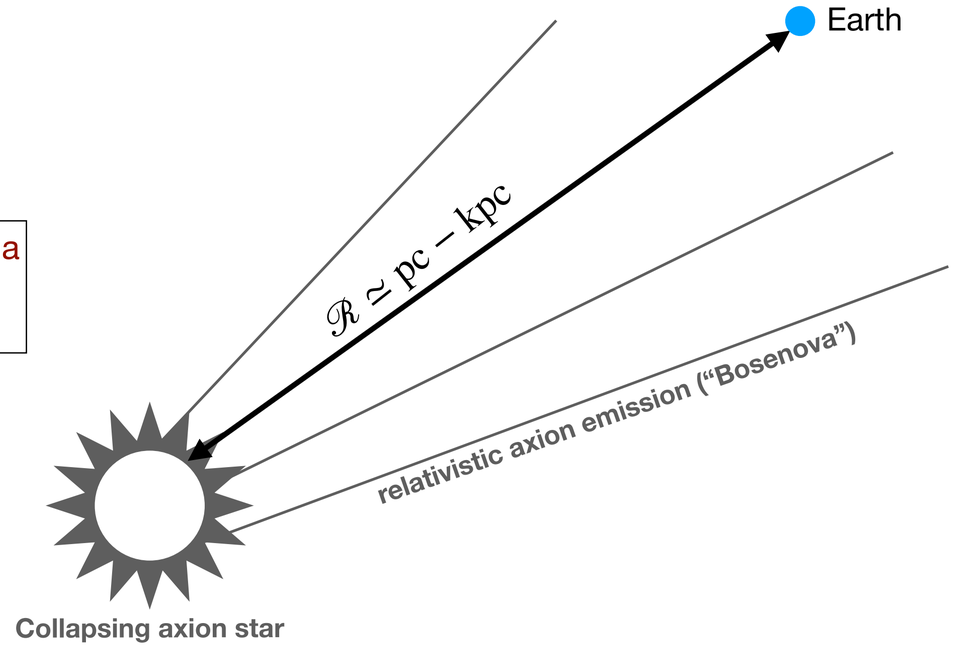
+ many papers in last decade!

The Proposal



Axion Star Explosions: A Target for Future Searches

When they become too massive, axion stars collapse and explode



Previous work: first prediction of Bosenova in axion star collapse

J Eby, Leembruggen, Suranyi, Wijewardhana
J. High Energy Phys. (2016) 2016: 66
J. High Energy Phys. (2017) 2017:14

Our study shows that emission of relativistic axions from axion stars a novel target for direct searches

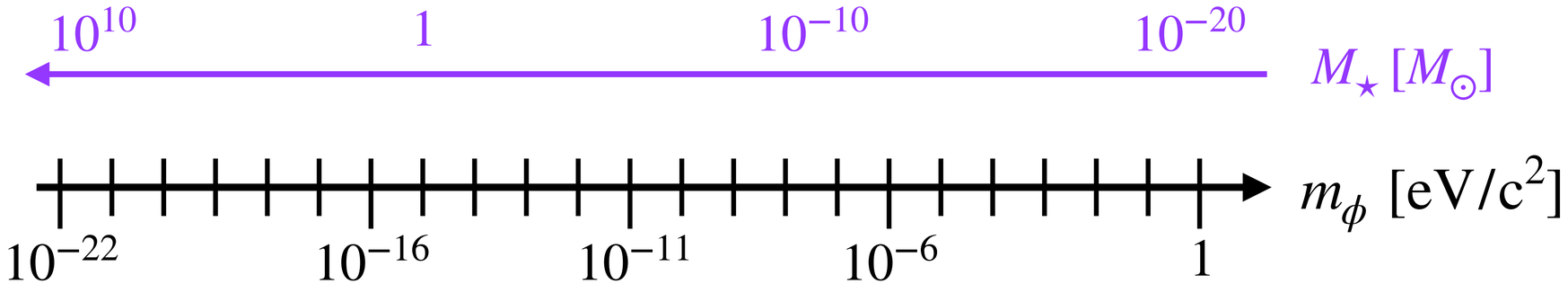
J Eby, Shirai, Stadnik, Takhistov
Phys. Lett. B 825 (2022) 136858

Broader range of experimental searches for relativistic axions from axion stars

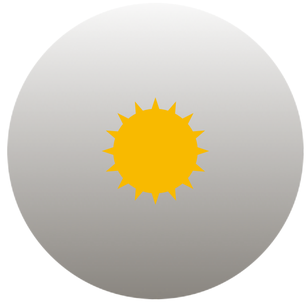
Arakawa, **J Eby**, Safronova, Takhistov, Zaheer
(in preparation)

Relativistic burst signals from extragalactic sources

J Eby, Takhistov
(in preparation)

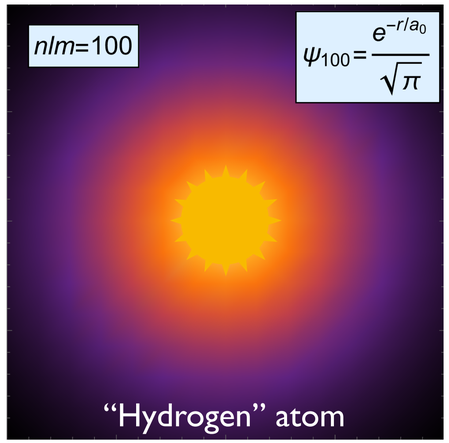


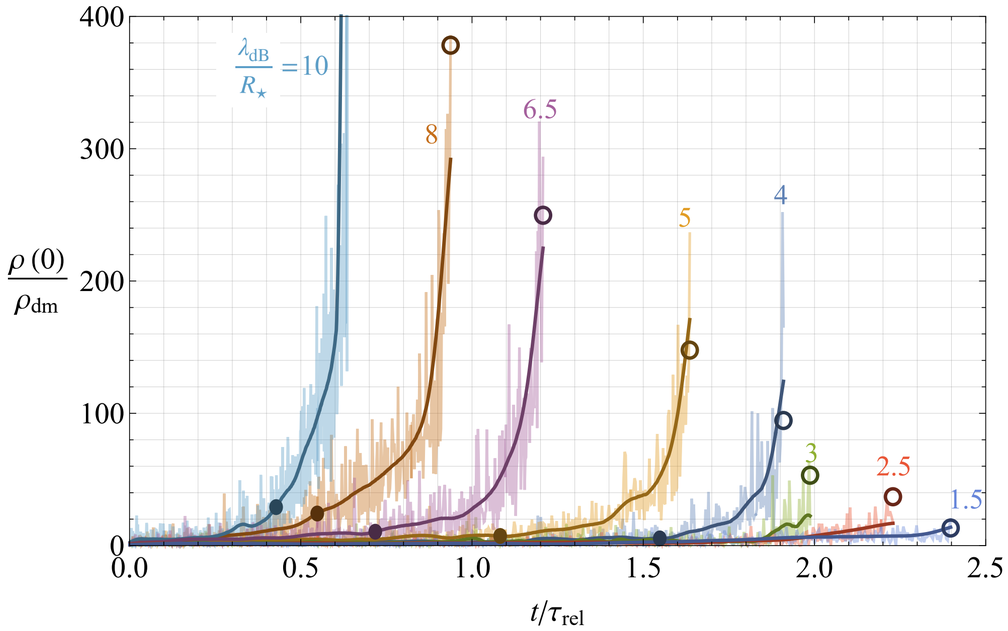
Formation of Axion Bound States



Gravitational Atoms

$\simeq$





Previous work: study of axions bound around astrophysical bodies (e.g. Earth and Sun)

Banerjee, Budker, **J Eby**, Kim, Perez, Communications Physics 3, 1 (2020)

with Flambaum, Matsedonskyi J. High Energy Phys. 09(2020) 004

Rapid formation of axion bound state in our Solar System

Budker, **J Eby**, Gorghetto, Jiang, Kim, Perez (in preparation)

Broad and important implications for terrestrial and astrophysical searches!