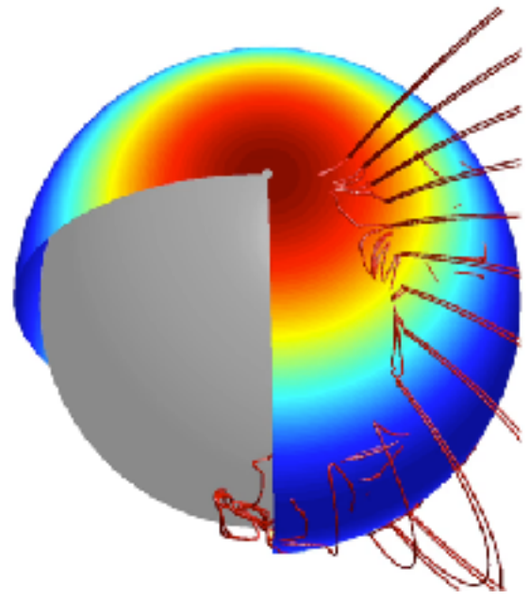


Theoretical Astrophysics Group

Neutron stars: binary interaction, flares, outbursts and glitches

Konstantinos N. Gourgouliatos
University of Patras - Department of Physics

Charis Anastopoulos, University of Patras - Department of Physics

Group members: Dimitrios Ntotsikas, Nikolitsa Psylla, Triantafyllos Kormpakis, Vera Agalianou, Athanasia Papaioannou (PhD and Master's Students)

External collaborators: Maxim Lyutikov (Purdue), Serguei Komissarov, Rainer Hollerbach, Andrei Igoshev (Leeds), Andrew Cumming (McGill), Dave Tsang (Bath), Sam Lander (Norwich), Toby Wood (Newcastle)

ΛISA in Greece 1st Workshop - Wednesday 23 February 2022

Research Areas

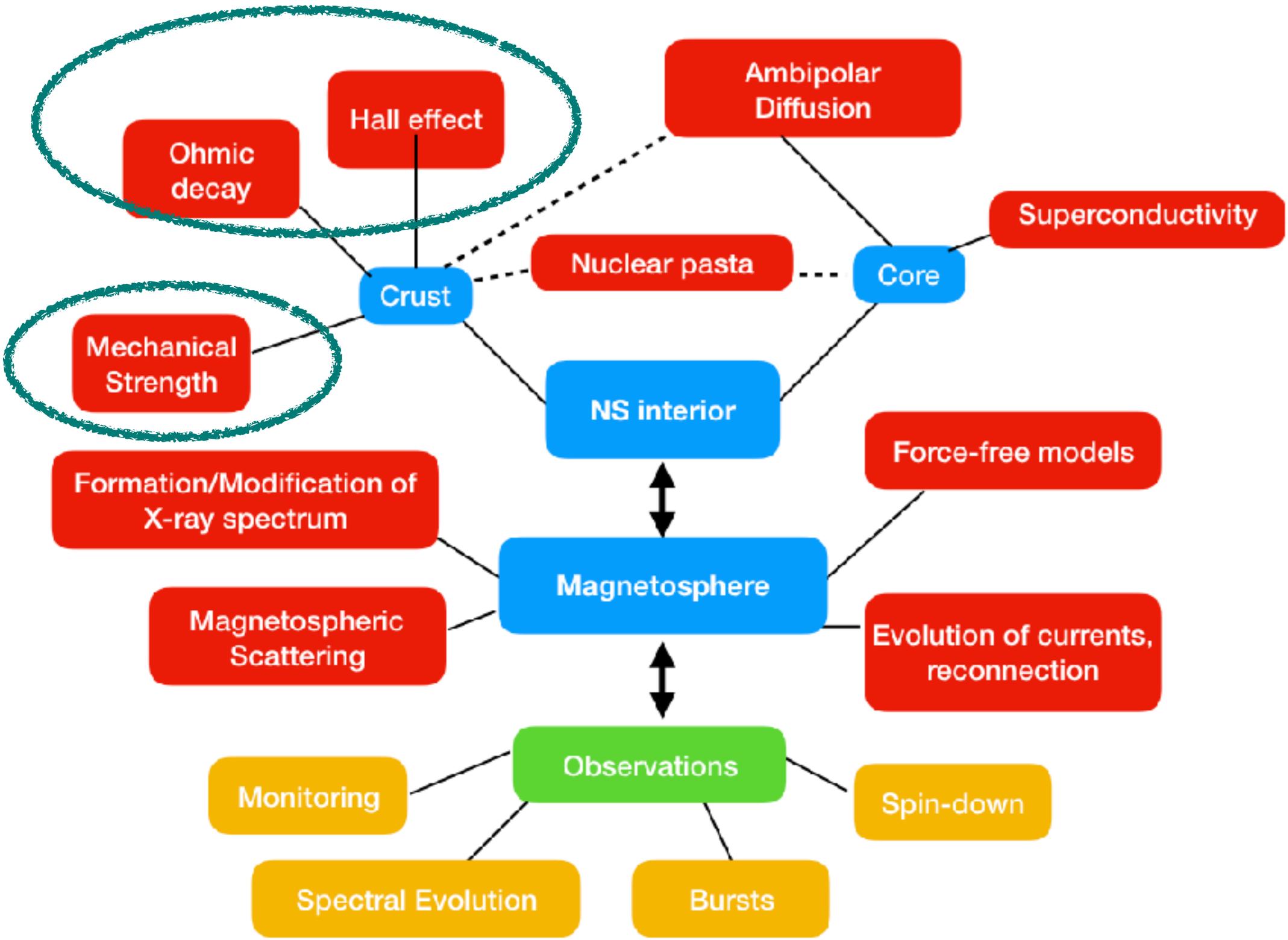
- Neutron stars:

- - Magnetic field structure and evolution.

  - - Crustal magnetic field evolution.
    - Magnetospheric field structure.
    - Crust failure: bursts and flares.
    - Glitches.

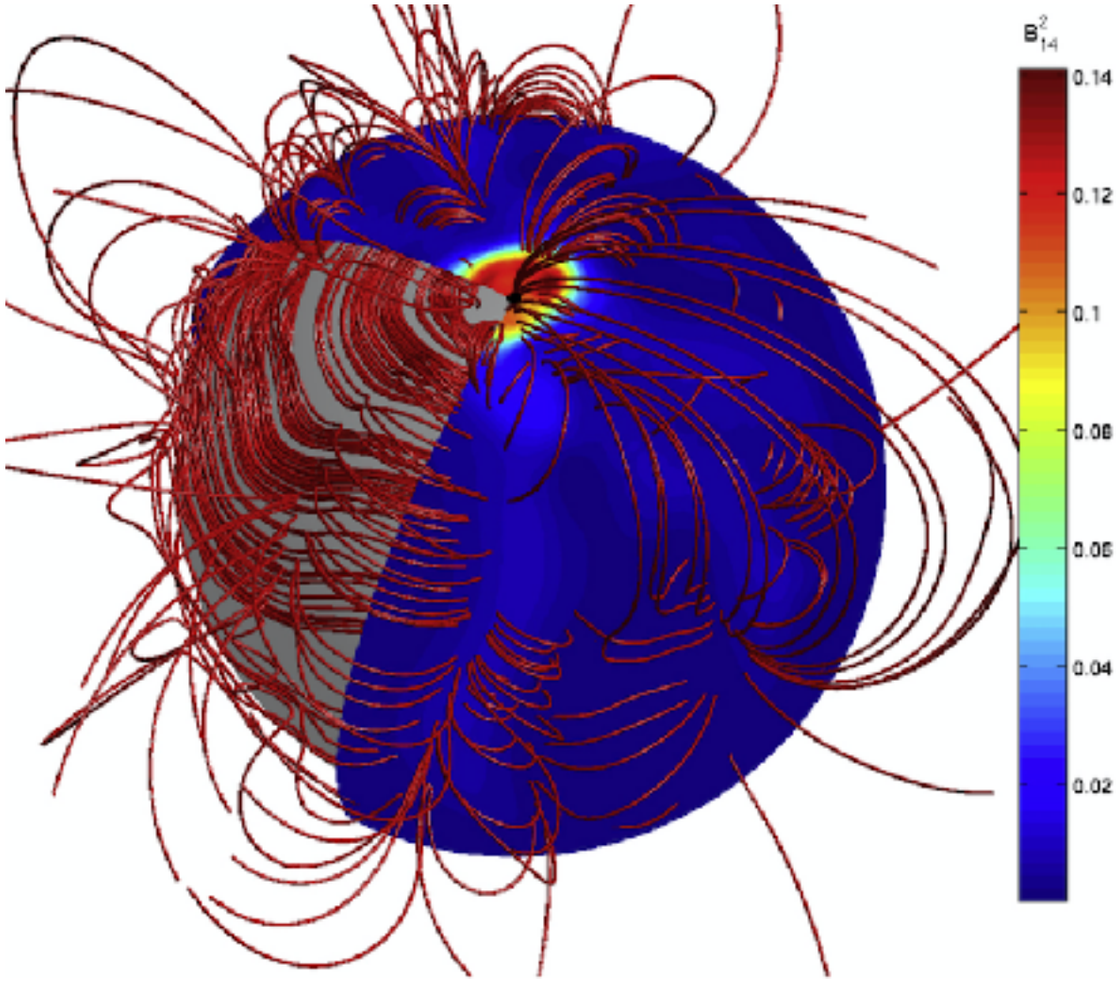
- Double neutron stars - interacting magnetospheres.

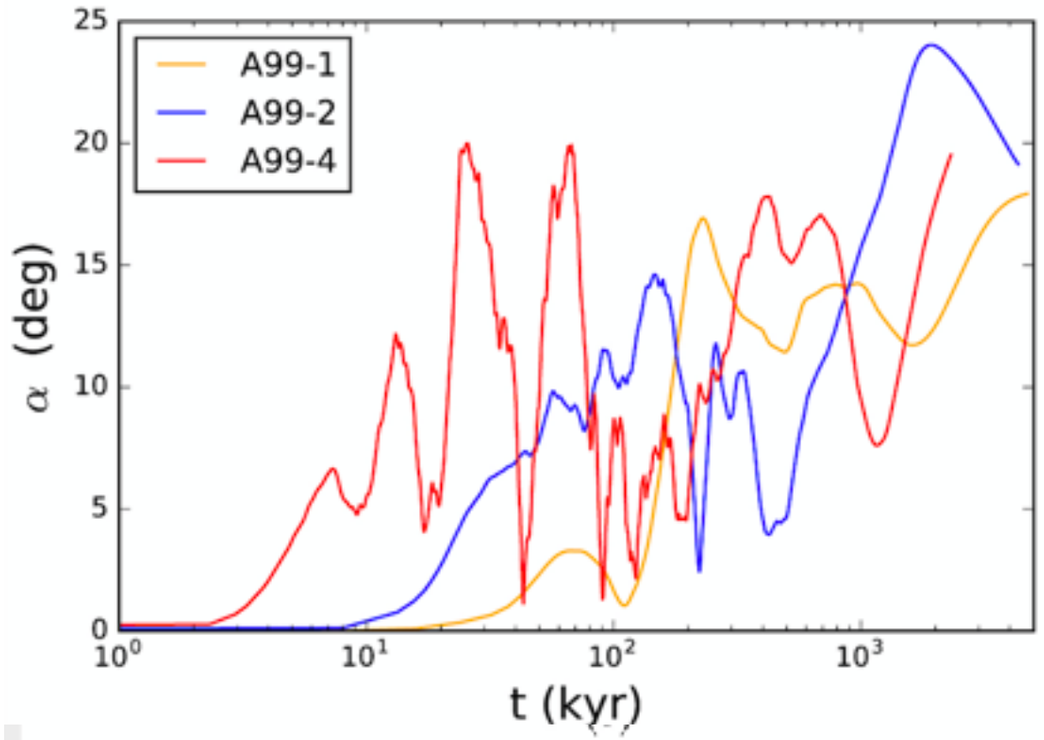
  - - Double Pulsar J0737-3039.
    - Pulsar wind - magnetosphere interaction.
    - Close encounters: strong deformation, E/M signals prior to merger.

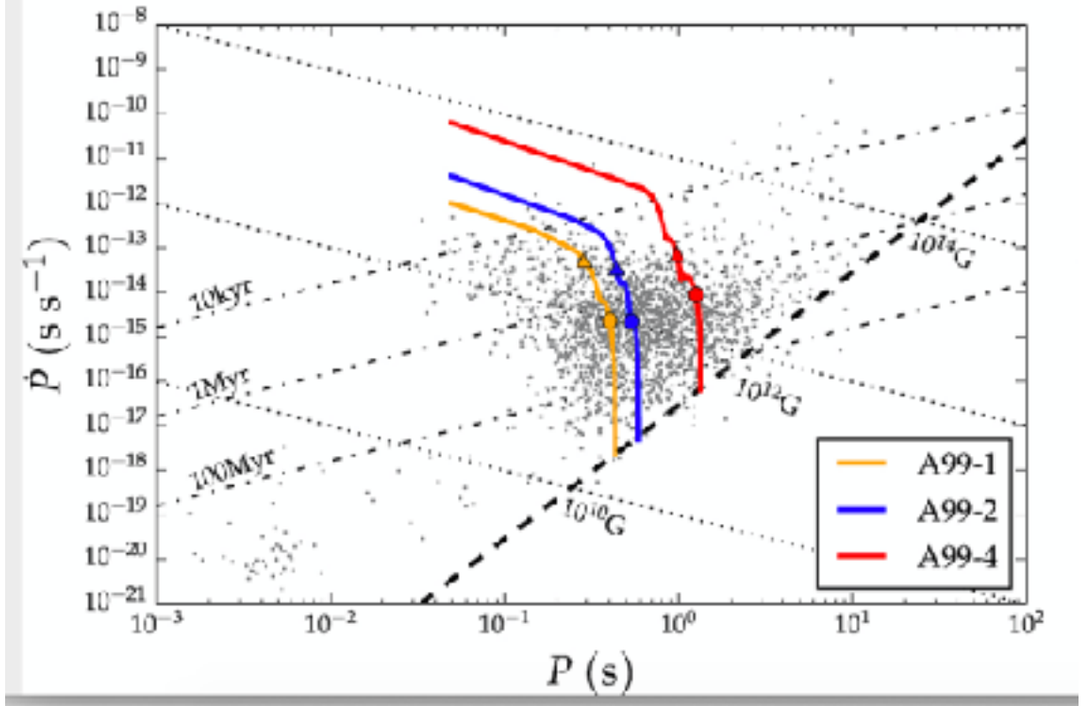

Ohmic decay
Hall effect
Ambipolar Diffusion
Superconductivity
Nuclear pasta
Crust
Core
Mechanical Strength
NS interior
Force-free models
Formation/Modification of X-ray spectrum
Magnetosphere
Magnetospheric Scattering
Evolution of currents, reconnection
Observations
Monitoring
Spin-down
Spectral Evolution
Bursts

Simulations of Crustal Magnetic Field Evolution

Formation of single spots: strong magnetic fields lead to surface deformations “mountains” associated to GW.
Crust failure: bursts, flares and glitches.

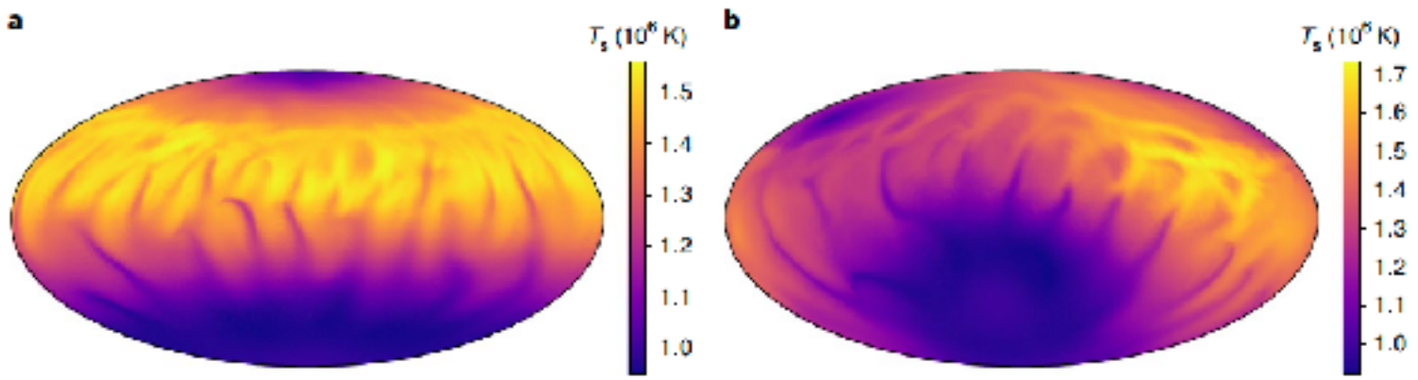






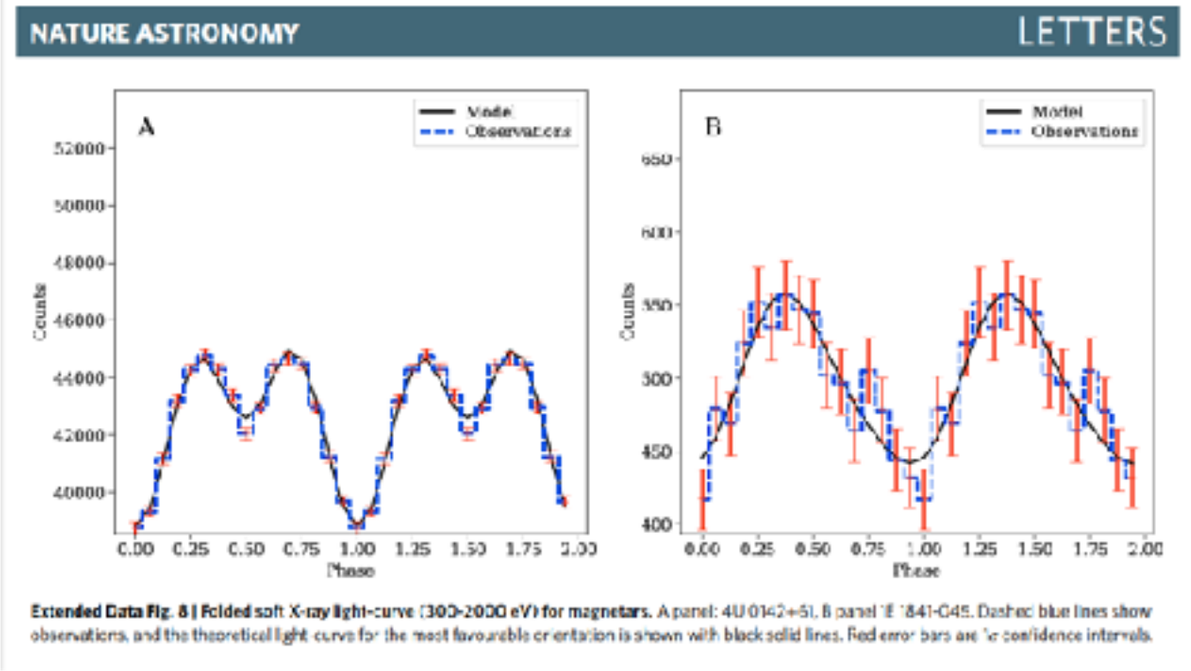
KG, Hollerbach & Wood 2015
KG & Hollerbach 2018
KG, Hollerbach & Igoshev 2019
Lander & KG 2019
KG & Lander 2021

Magnetothermal 3-D Evolution



Successfully model 10 quiescent magnetar X-ray light curves.

Thermal evolution: possibility of deformation, association with outbursts and quiescent evolution - associated with GWs.



Extended Data Fig. 8 | Folded soft X-ray light-curve (300–2000 eV) for magnetars. A panel: 4U 0142+61, B panel: 1E 1841-045. Dashed blue lines show observations, and the theoretical light curve for the most favourable orientation is shown with black solid lines. Red error bars are 1σ confidence intervals.

Igoshev, Hollerbach, Wood & KG, Nat. Ast. 2021

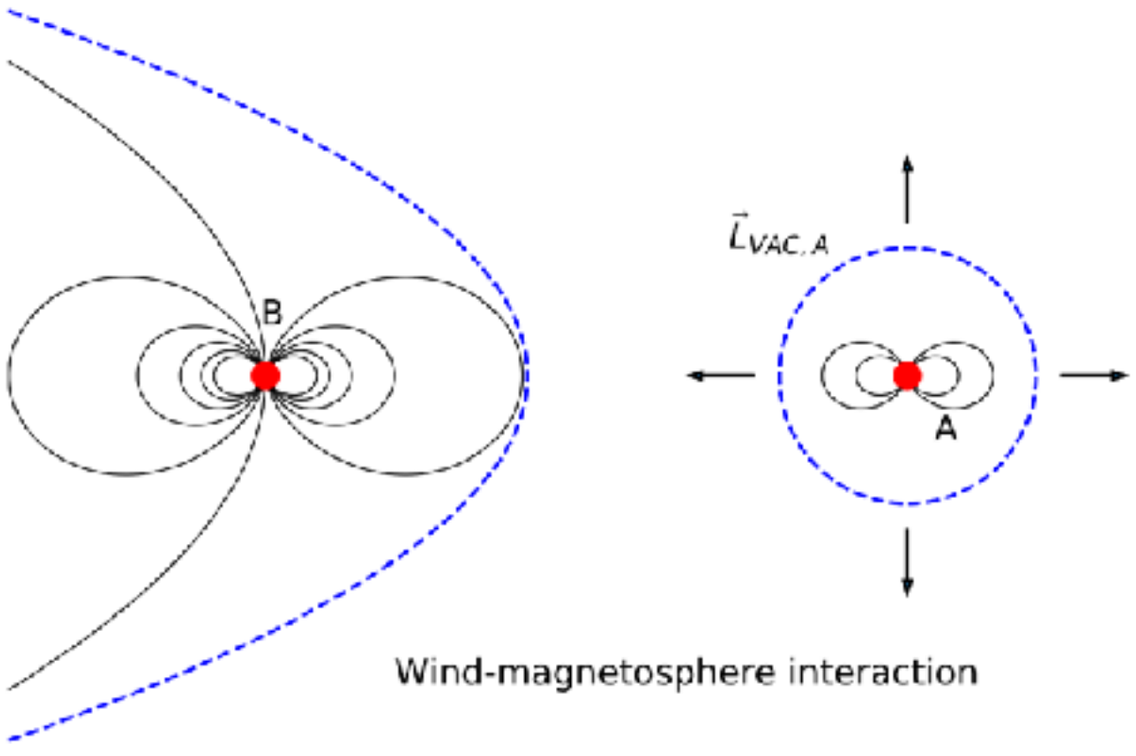
Double Neutron Stars

Wind-magnetosphere interaction

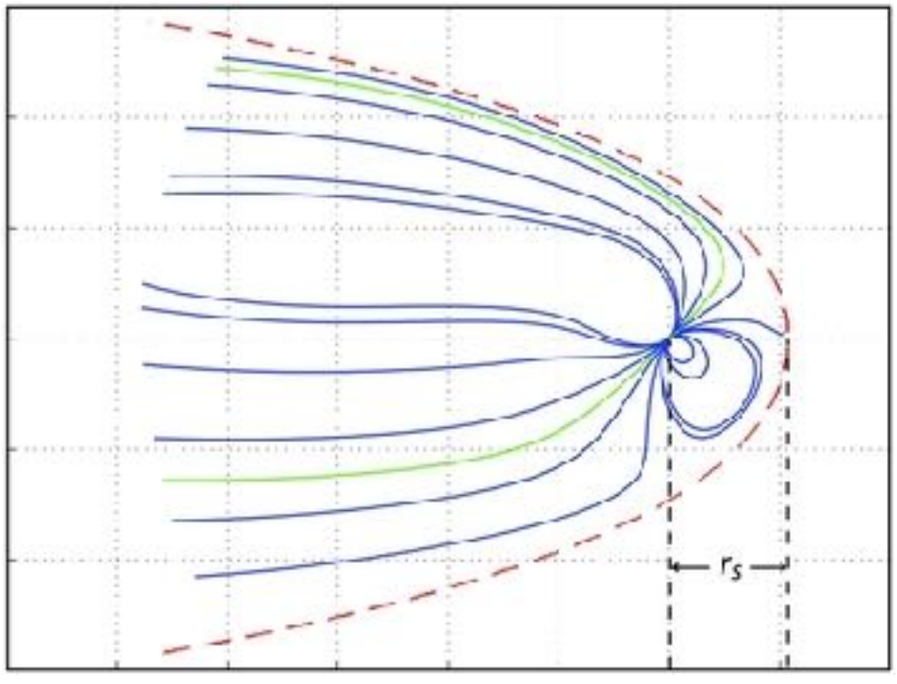
$$P_A \ll P_B$$

$$B_A \ll B_B$$

Magnetic pressure of B at its light-cylinder



Wind-magnetosphere interaction

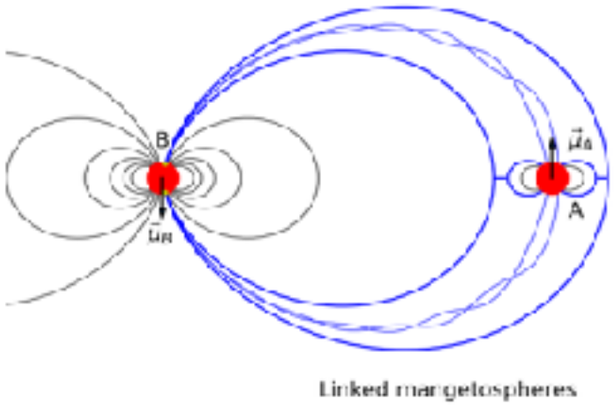


Perera, Lomiashvilli, KG+ 2012
KG et al. 2011

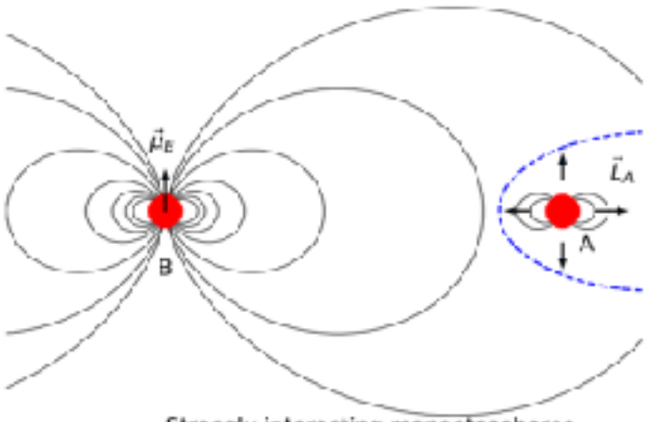
J0737-3039 A/B

Pulsar A in the magnetosphere of B

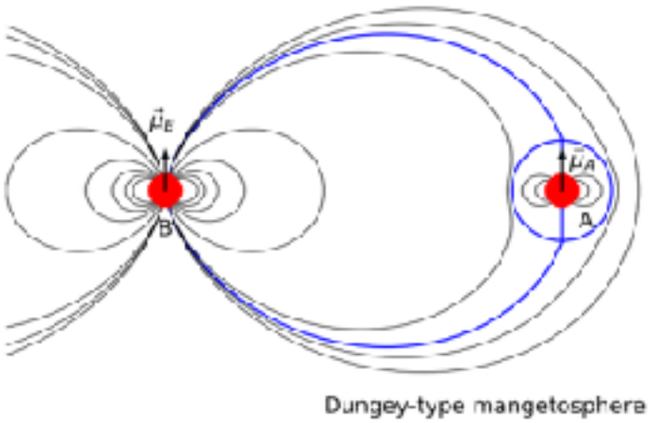
Strongly interacting phase



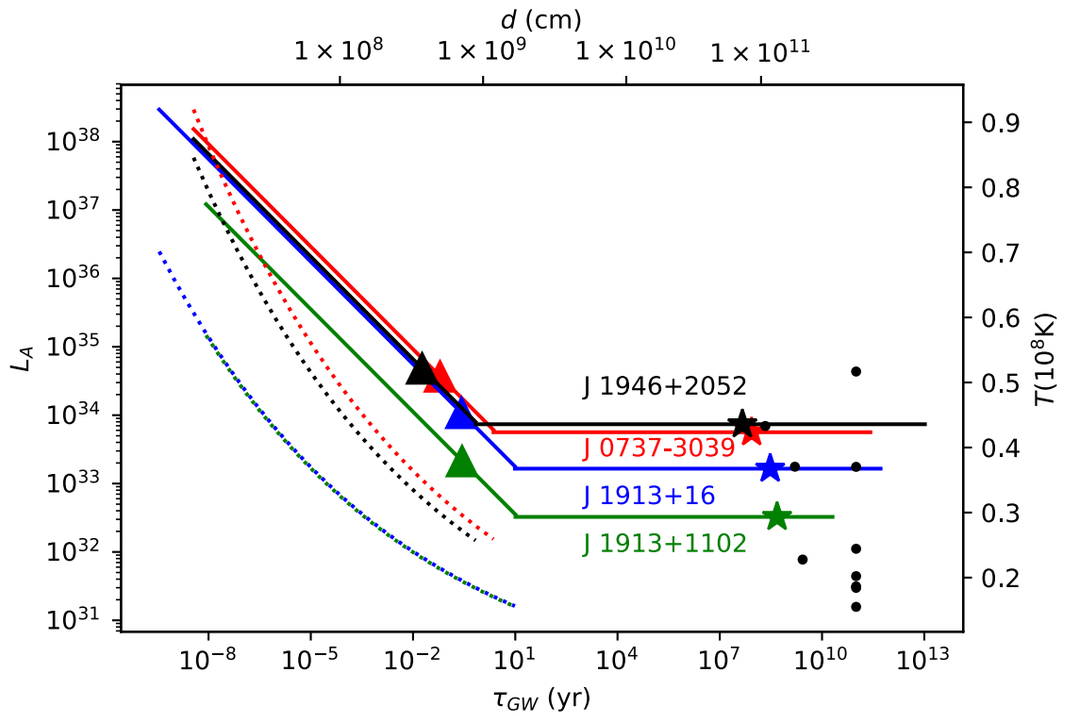
Linked mangetospheres



Strongly interacting mangetospheres

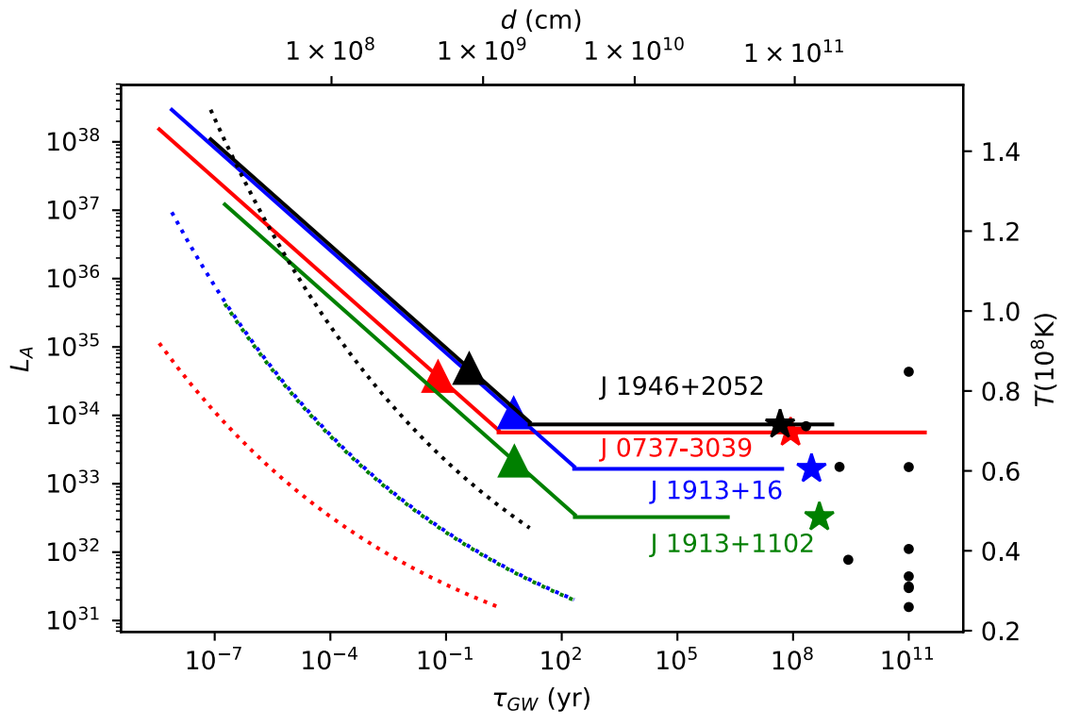


Dungey-type mangetosphere



P_B=1s

$B_B=10^{12}$G



P_B=1s

$B_B=10^{13}$G

KG & Lynden-Bell 2019

Stochastic / quantum backgrounds of gravitational waves

- A stochastic background as a source of decoherence in quantum systems. Implications for fundamental physics. The Anastopoulos-Blencowe-Hu (ABH) model of gravitational decoherence

- C. Anastopoulos and B. L. Hu. A master equation for gravitational decoherence: Probing the textures of spacetime. Class. Quantum Grav. 30:165007, 2013.
- M. Blencowe. Effective field theory approach to gravitationally induced decoherence. Physical Review Letters, 111:021302, 2013.

- Can we identify primordial gravitons from the noise induced by gravitational waves?

- M. Parikh, F. Wilczek and G. Zahariade, The Noise of Gravitons, Int. J. Mod. Phys. D29,2042001 (2020).

- Can we distinguish between the predictions of quantum gravity theories (e.g. regarding lightcone fluctuations) by gravitational effects in macroscopic quantum systems?

- C. Anastopoulos, M. Lagouvardos and K. Savvidou, Gravitational effects in macroscopic quantum systems: a first-principles analysis, Class. Quantum Grav. 38, 155012 (2021).

Charis Anastopoulos Group

ΛISA in Greece 1st Workshop - Wednesday 23 February 2022

Deep Space Quantum Link

- A NASA program that could test the ABH proposal for gravitational decoherence. (And many other phenomena at the interplay of gravity and quantum).
- The experiments are planned in relation to the **Lunar Gateway** space station, in the late 2020s.
- Hope: find **new physics** exploiting long baselines for quantum experiments in deep space.

The Deep Space Quantum Link: Prospective Fundamental Physics Experiments using Long-Baseline Quantum Optics

Makan Mohageg,[1,*] Luca Mazzarella,[1] Dmitry V. Strekalov,[1] Nan Yu,[1] Aileen Zhai,[1] Spencer Johnson,[2] Charis Anastopoulos,[3] Jason Gallicchio,[4] Bei Lok Hu,[5] Thomas Jennewein,[6] Shih-Yuin Lin,[7] Alexander Ling,[8] Christoph Marquardt,[9] Matthias Meister,[10] Albert Roura,[10] Lisa Wörner,[10] Wolfgang P. Schleich,[10,11,12] Raymond Newell,[13] Christian Schubert,[14,15] Giuseppe Vallone,[16,17,18] Paolo Villoresi,[16,17] and Paul Kwiat[2,†]

[1] *Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, U.S.A.*
[2] *Dept. of Physics, University of Illinois at Urbana-Champaign; Illinois Quantum Information Science & Technology Center, Urbana, Illinois, U.S.A.*
[3] *Department of Physics, University of Patras, Patras, Greece*
[4] *Department of Physics, Harvey Mudd College, Claremont, California, U.S.A.*
[5] *Maryland Center for Fundamental Physics and Joint Quantum Institute,*

Arxiv: 2111:15591

Charis Anastopoulos Group

ΛISA in Greece 1st Workshop - Wednesday 23 February 2022

Thanks for your attention!

www.astro.upatras.gr