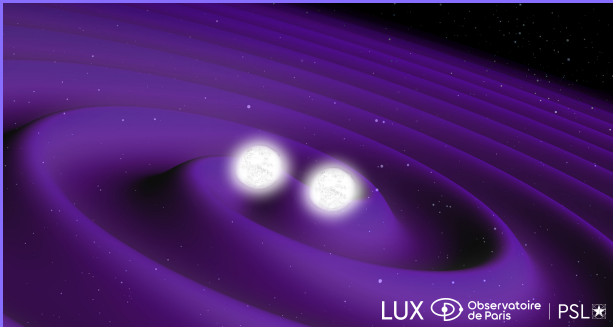


Présentation de l'équipe ASTRE

Laura Bernard

Journée de lancement du LUX

14 mars 2025, Paris – salle Cassini



Research topics

Study of **compact objects** and **gravitational theories** to improve our understanding of extreme processes in the Universe.

Objects & concepts

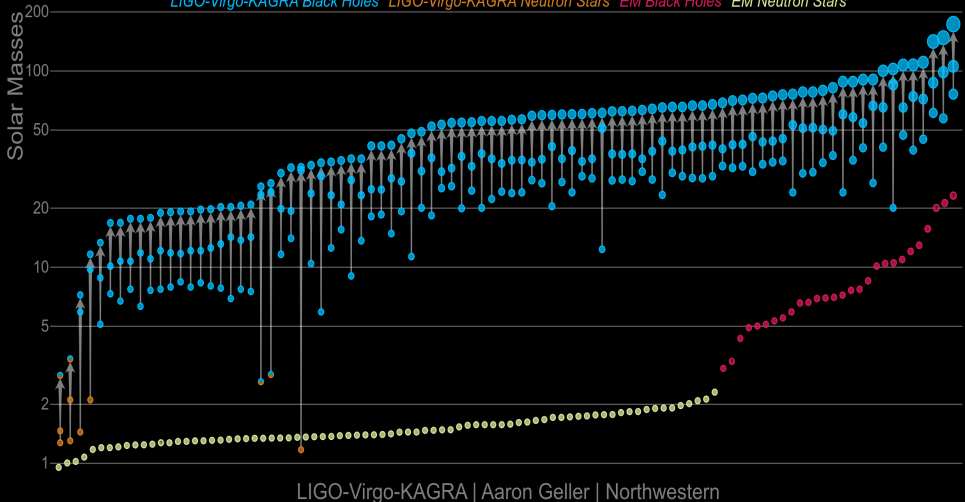
- black hole, neutron stars, pulsars
- Fast radio bursts, GRBs, AGNs
- general relativity, alt. theories
- wind, jet and shocks

Methodology

- modeling
- observation
- simulation
- theory

Masses in the Stellar Graveyard

LIGO-Virgo-KAGRA Black Holes *LIGO-Virgo-KAGRA Neutron Stars* *EM Black Holes* *EM Neutron Stars*



From theory to modelisation/simulations to observations

- Numerical tools:

Numerical libraries LORENE, KADATH

Ray-tracing code GYOTO

Computer algebra system SageManifolds

Kinetic	PIC-Spectral	Fluide	Radiative transfert	<u>Chronométrage de pulsar</u>
EMBLEM	AROMA	AMRVAC	Riptide	<u>Nutimo</u>

- Collaborations:



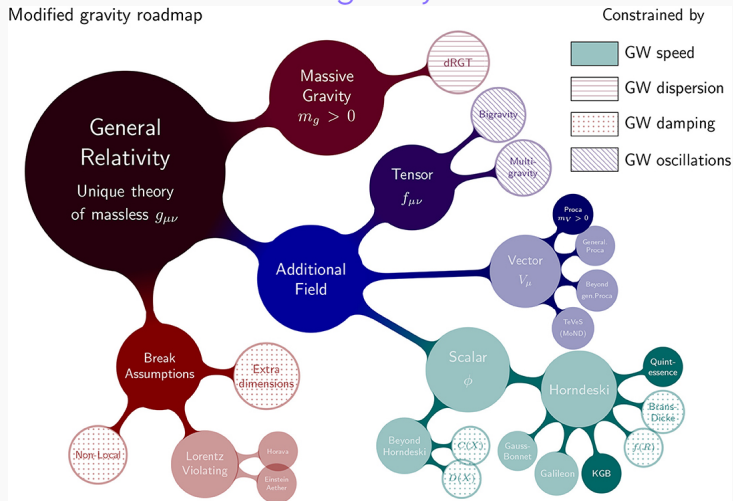
Einstein
Telescope



Theories of gravity

Alternative theories of gravity

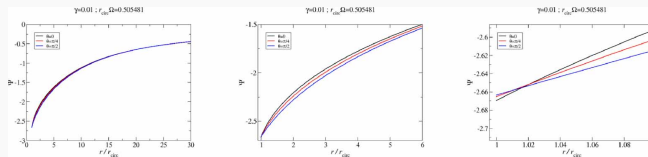
Modified gravity roadmap



L. Bernard, H. Candan, E. Dones, P. Grandclément, E. Gourgoulhon, S. Mougiakakos

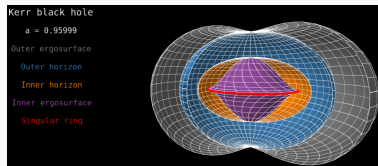
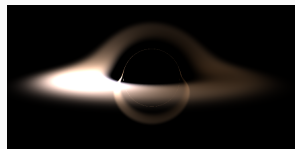
Theories of gravity

Rotating hairy solutions in cubic galileon theory



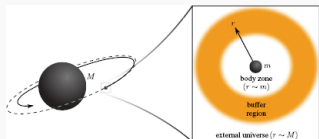
- scalar field profile (obtained with KADATH)

BH imaging

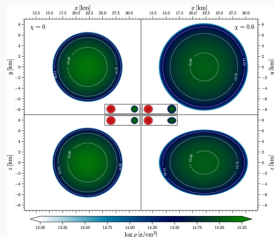


- studies of BH solutions with SageManifold

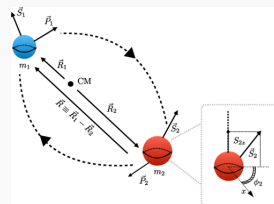
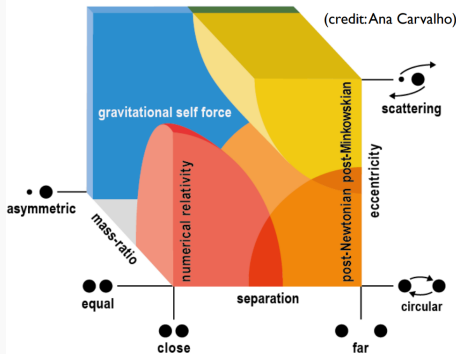
Gravitational wave modeling



extreme mass ratio inspirals



initial data for spinning BNS



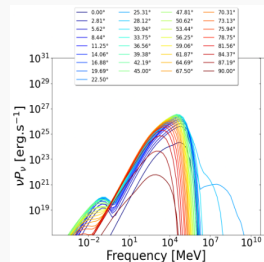
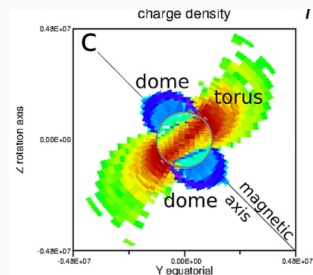
inspiral of spinning compact binaries

L. Bernard, H. Candan, T. Colin, E. Dones, P. Grandclément, E. Gourgoulhon, A. Le Tiec, S. Mouriakakos, S. Tanay

Modélisation: pulsar magnetospheres

Electrospheres

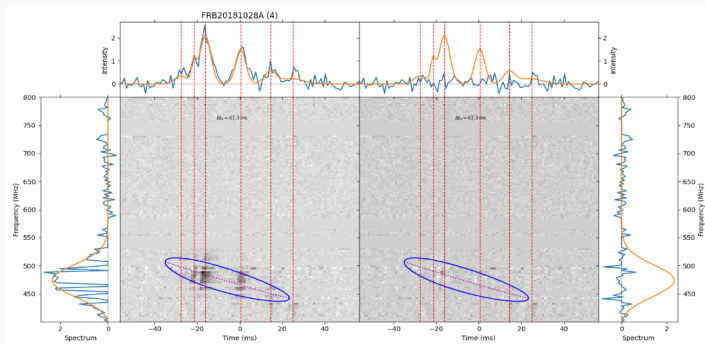
- neutron star magnetosphere in which all particles originate directly from the star
 - characterized by: magnetic inclination; total electric charge
 - ARoMa code
 - higher energy emission than pulsars
 - diffuse galactic emission: FERMI-LAT



T. Francez, F. Mottez, G. Voisin

Modélisation to observation: FRBs

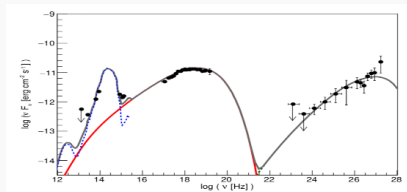
Fast Radio Bursts



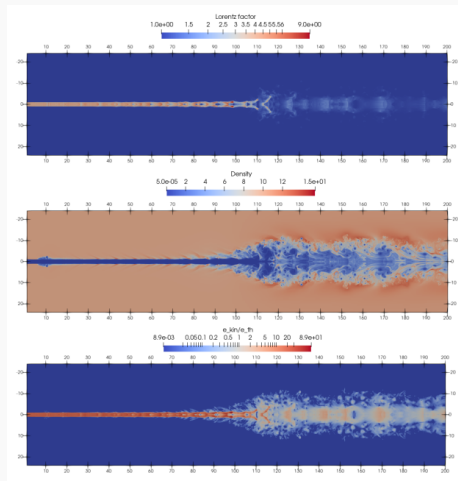
- possibly originating from exotic magnetars
- phenomenological models of FRB, using the burst morphology

Modelisation: particles acceleration in shocks

TeV blazars



- co-acceleration of electrons and protons in shocks
- low magnetic fields
- very high minimum Lorentz factor

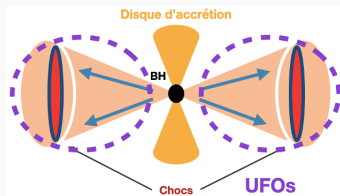


- knots originating from shocks in jets

P. Cristofari, B. Le Nagat Neher, Z. Meliani, A. Zech

Modelisation: AGN winds

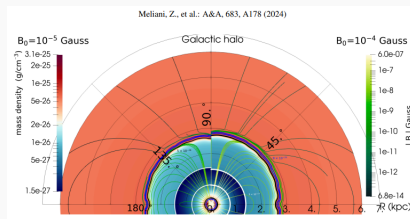
Ultra Fast Outflows



- mildly relativistic velocity and wide opening angle
- candidates for accelerating ultra-high energy cosmic rays

Galactic bubbles

- MHD simulations with the AMRVAC code
- dipolar magnetic field

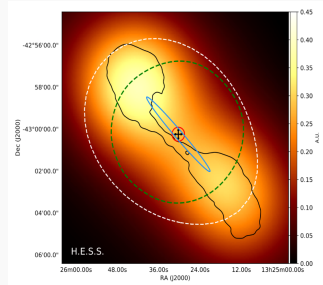


P. Cristofari, B. Le Nagat Neher, Z. Meliani, A. Zech

Observations: gamma-rays

H.E.S.S. observations

- multiwavelength image of Centaurus A at TeV energies
- acceleration of ultra-relativistic electrons in the jet

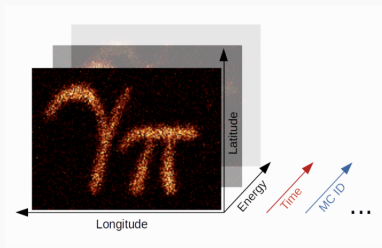


The H.E.S.S. Collab., Nature 582, 356–359 (2020)

CTAO

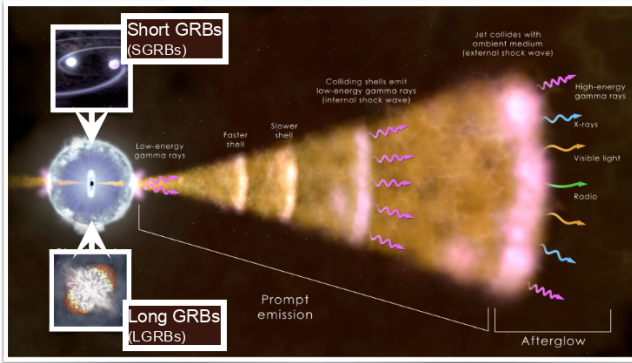


- data access: Science Portal and Science Archive
- data analysis: open-source Python package `gammapy`

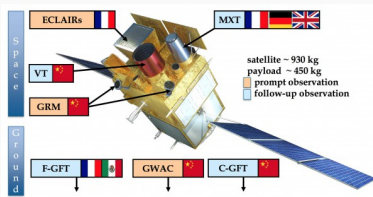


O. Ates, C. Boisson, P. Cristofari, M. Servillat, H. Sol, A. Zech

Observations: gamma ray bursts



[Credits: NASA]



SVOM

- ultra-relativistic jets linked to the cataclysmic formation of BHs
- **Stargate**: GRB follow-up at the VLT

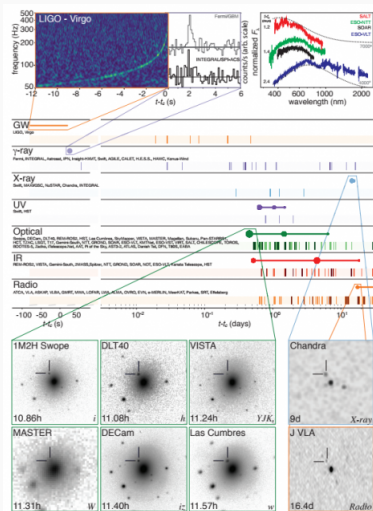


V. Abril-Melgarejo, S. Bisero, Y. Canton, M. Garnichey, S. Vergani

Observations: multimessenger astronomy

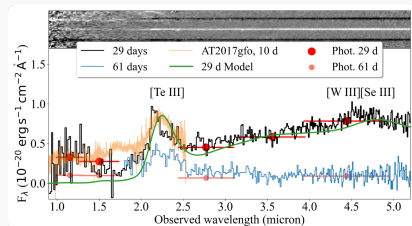
GW170817

Engrave collaboration



[LIGO-Virgo collab., 2017]

- Electromagnetic counterparts of gravitational wave sources at the Very Large Telescope



[Levon et al., Nature 626 (2024) 8000, 737-741]

- JWST spectrum of the KN counterpart of GRB 230307A, detectable with Einstein Telescope

V. Abril-Melgarejo, S. Bisero, Y. Canton, M. Garnichey, S. Vergani

Conclusion

Questions ?



Merci !