Astrofisica relativistica e particellare

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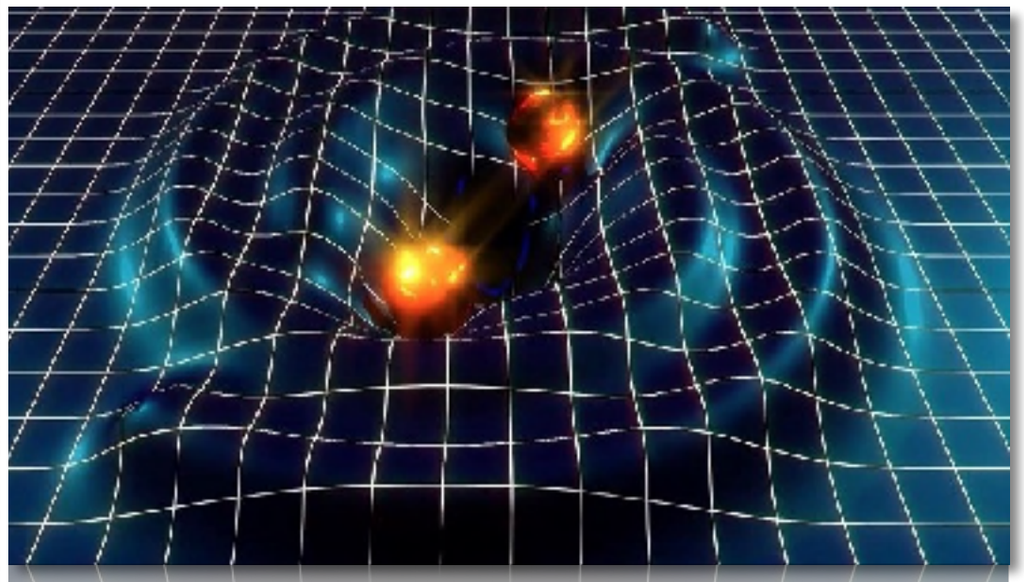

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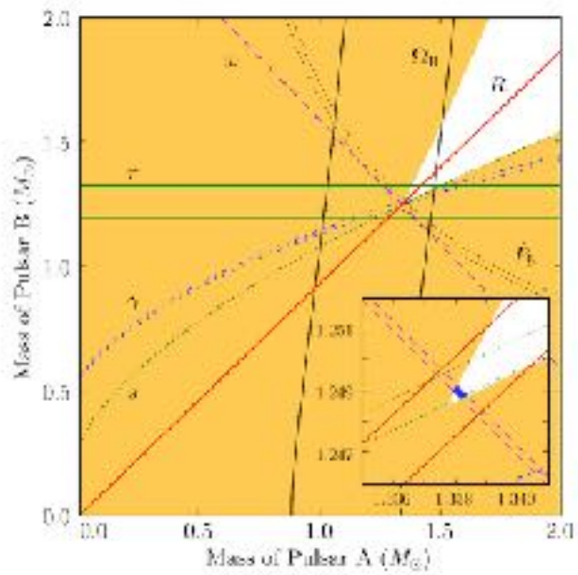
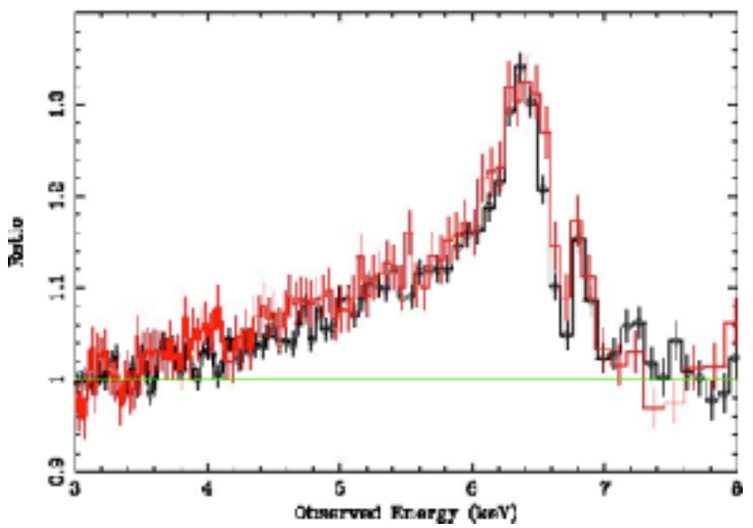
KEY QUESTIONS

- Reveal and study the effects of GR in the strong field limit
- Measure the properties of BHs (mass, spin) and understand how energy is extracted from them
- Physics of accretion and ejection onto/from compact objects
- Study the particle acceleration processes at all different scales
- Search for electromagnetic counterparts of gravitational waves and of neutrino sources
- Use the compact objects and high-energy observations to constrain fundamental laws of nature (e.g. Lorentz Invariance Violation, axion-like particles, dark matter)

BLACK HOLES AND COMPACT OBJECTS

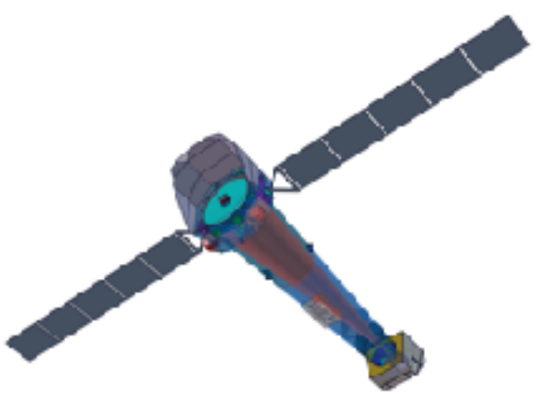
- GW detections prove directly the existence of BH
- EH telescope: direct imaging of event horizon soon?
- For stellar-mass black holes, methods for measuring M,i
- Best laboratories for studying (and confirming) GR
- Binary compact objects: double pulsar, WD-pulsar, BH-pulsar?



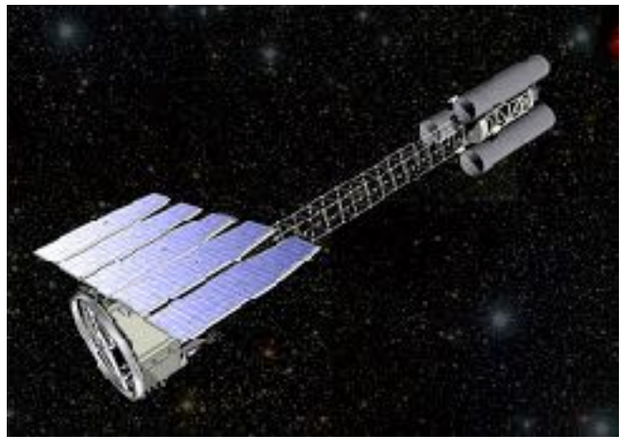


BLACK HOLES AND COMPACT OBJECTS

- Need to disentangle accretion and GR effects
- Broad-band coverage for continuum. High-resolution.
- High-time resolution and throughput for timing
- Polarization
- Radio measurements and monitoring of binary objects



Athena

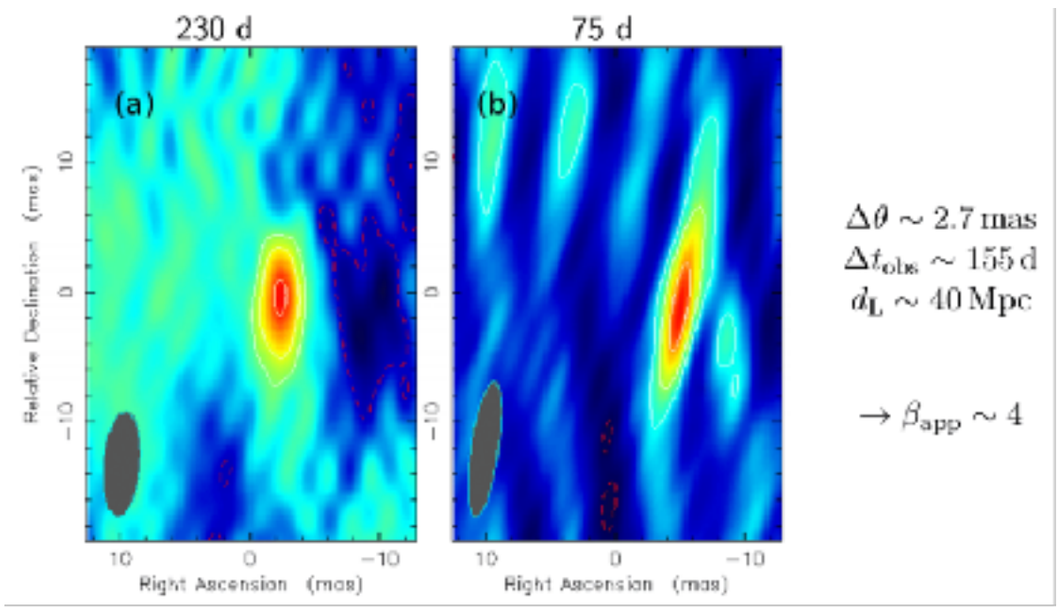


IXPE

eXTP

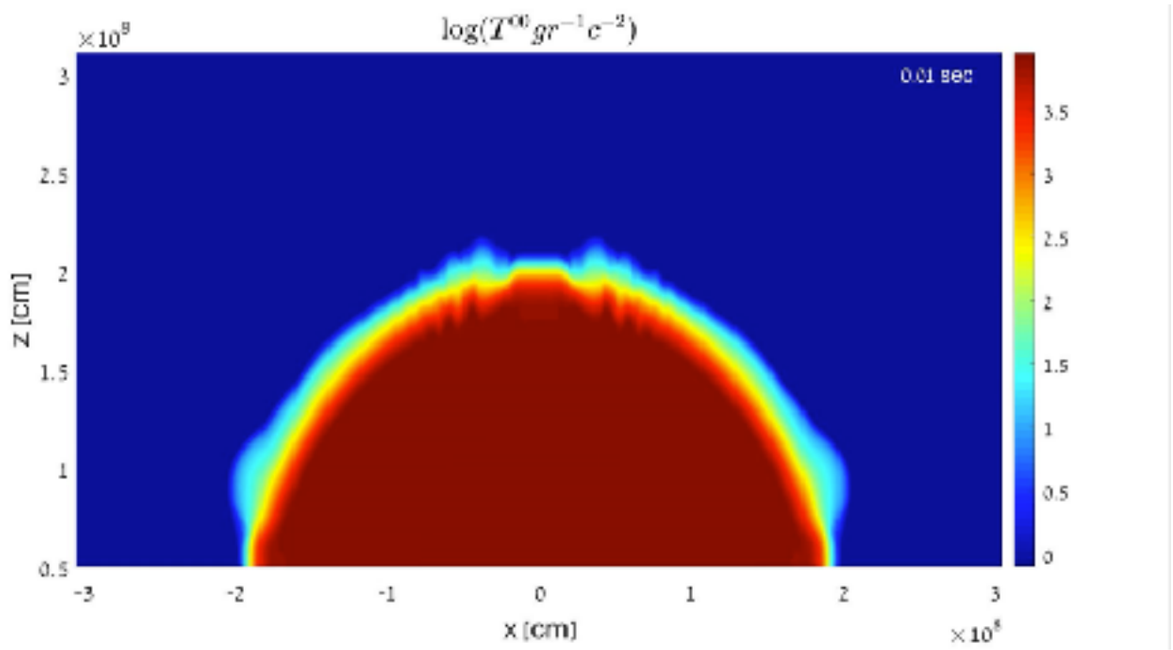
GRAVITATIONAL WAVES

- GW event of 17/08/2017: NS-NS merger
- EM counterpart: short GRB, optical kilonova
- R-processes nucleosynthesis
- MBHBs: nano-HZ GW background from Pulsar Timing Array
- Window just opened: all wavelengths involved (+GW)



$\Delta\theta \sim 2.7\,\mathrm{mas}$
$\Delta t_{\mathrm{obs}} \sim 155\,\mathrm{d}$
$d_{\mathrm{L}} \sim 40\,\mathrm{Mpc}$

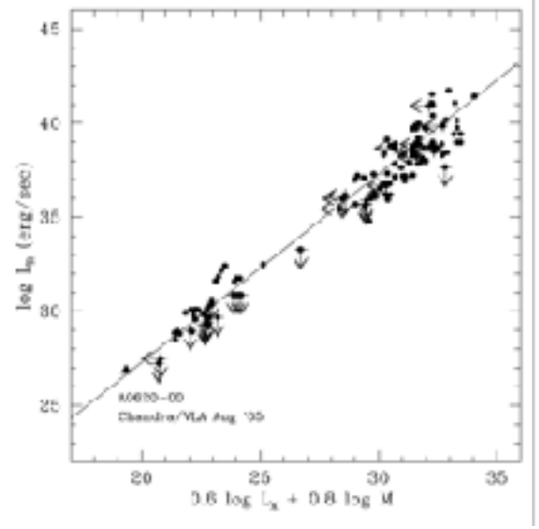
$\rightarrow \beta_{\mathrm{app}} \sim 4$



PHYSICS OF ACCRETION AND EJECTION

- Clear picture emerged in the last two decades
- Across scales: from WDs to AGN
- Coverage, spectra, timing, multi-λ, polarization
- Galactic Center: activity, flares, illumination
- Transitional msec psr: multi-λ coverage, faint systems
- AGN: multi-λ crucial, effect of galaxies, evolution
- Blazars: jets and particle acceleration - CR & neutrinos

  interaction with axions? Lorentz invariance breakdown
- FRB: probes of distant universe?
- ULX and pulsations: accretion models?

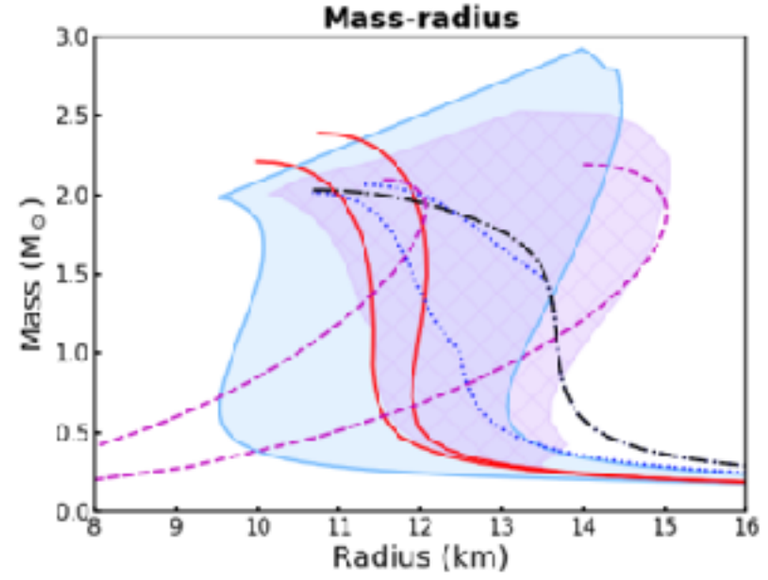


MATTER UNDER EXTREME CONDITIONS

- NS ideal (and unique) laboratories - equation of state
- Fast Quasi-Periodic Oscillations
- High-resolution spectroscopy of surface lines
- Pulsar timing (again double pulsar)
- Magnetars: life in a high B-field

  Hard components: cyclotron lines and vacuum polarization

  Giant flares: connection to short GRBs?
- Thermal emission from surface of INS

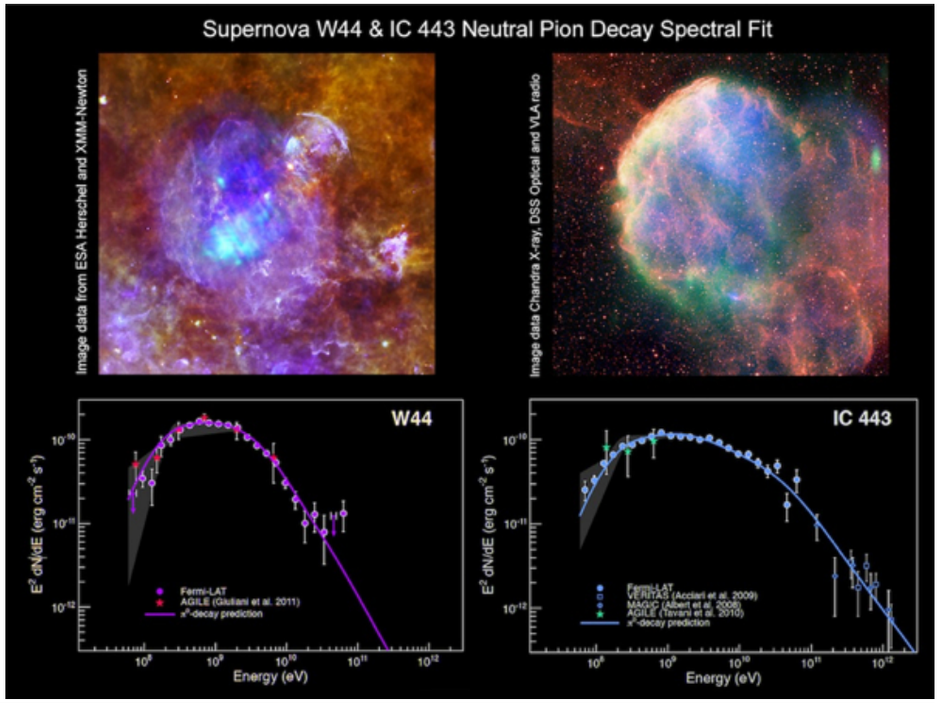


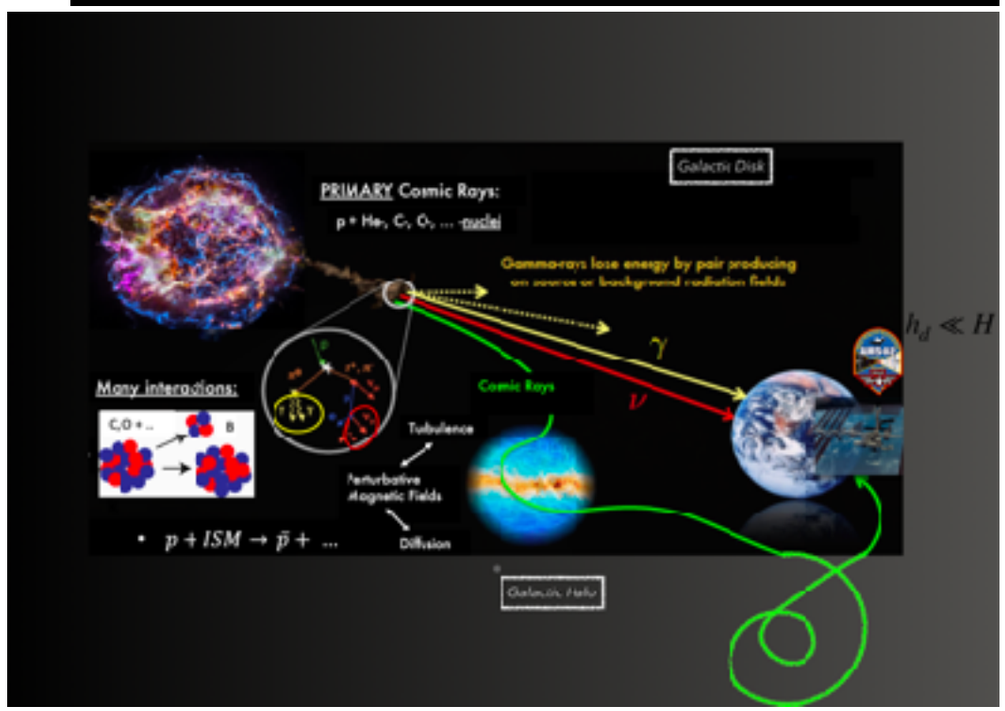
GAMMA-RAY BURSTS AND LUMINOUS SN

- GRB intrinsic physics: fireball, jets, particle acceleration
- Star formation rate, ISM of galaxies, probe reionization epoch, fundamental physics [largest z=9.2]
- Long/short GRBs
- Connection to SN - merger
- Need high-resolution spectra to trace time-variable features
- Polarization measurements -> B-dominated?
- High-energy afterglow observations, energy budget
- Mev-GeV: TeV emission? CTA

THE ORIGIN OF COSMIC RAYS

- Relativistic protons from SNR
- Breaks below the knee
- Anomaly in anti-matter
  neglected propagation effects
- Non-linear effects -> permanence,
  gamma-ray emission (Fermi, CTA)
- Positrons: pulsar wind nebulae, no
  dark matter, prediction with CTA?





THE TABLE

Key question	Method	Project
Physics of accretion and ejection onto/from compact objects	Efficient/inefficient accretion modes. Winds and jets. Numerical simulations.	Chandra, XMM, Swift, Nustar, radio and mm telescopes. SKA, Athena, CTA, Ligo-Virgo
Reveal and study the effects of GR in the strong field limit	X-ray timing and spectroscopy	Chandra, XMM, Swift, Nustar Athena
Measure the properties of BHs (mass, spin) and understand how energy is extracted from them	Broad Iron lines. Feedback: Interplay between galaxy and BH	Chandra, XMM, Swift, Nustar Athena
Study the particle acceleration processes at all different scales	Jet structures on small scales. Hot spots and radio lobes. Radio relics in clusters. SNR. PSR, GRB	Chandra, XMM, HST, radio and mm telescopes. SKA, Athena, CTA, IXPE
Search for electromagnetic counterparts of gravitational waves and of neutrino sources	EM counterparts of GW sources. GRB. Blazars-Radio galaxies as possible sources of neutrinos.	Ligo-Virgo and all the available telescopes/satellites CTA
Use the compact objects and high-energy observations to constrain fundamental laws of nature (e.g. Lorentz Invariance Violation, axion-like particles, dark matter)	Blazar spectra at TeV energies Wimps	CTA, Athena