

NICER

Neutron Star Interior Composition
Explorer



New Results from the Neutron Star Universe

-NICER Mission: 3 Years in June 2020-

Natalia Lewandowska
(Haverford College)

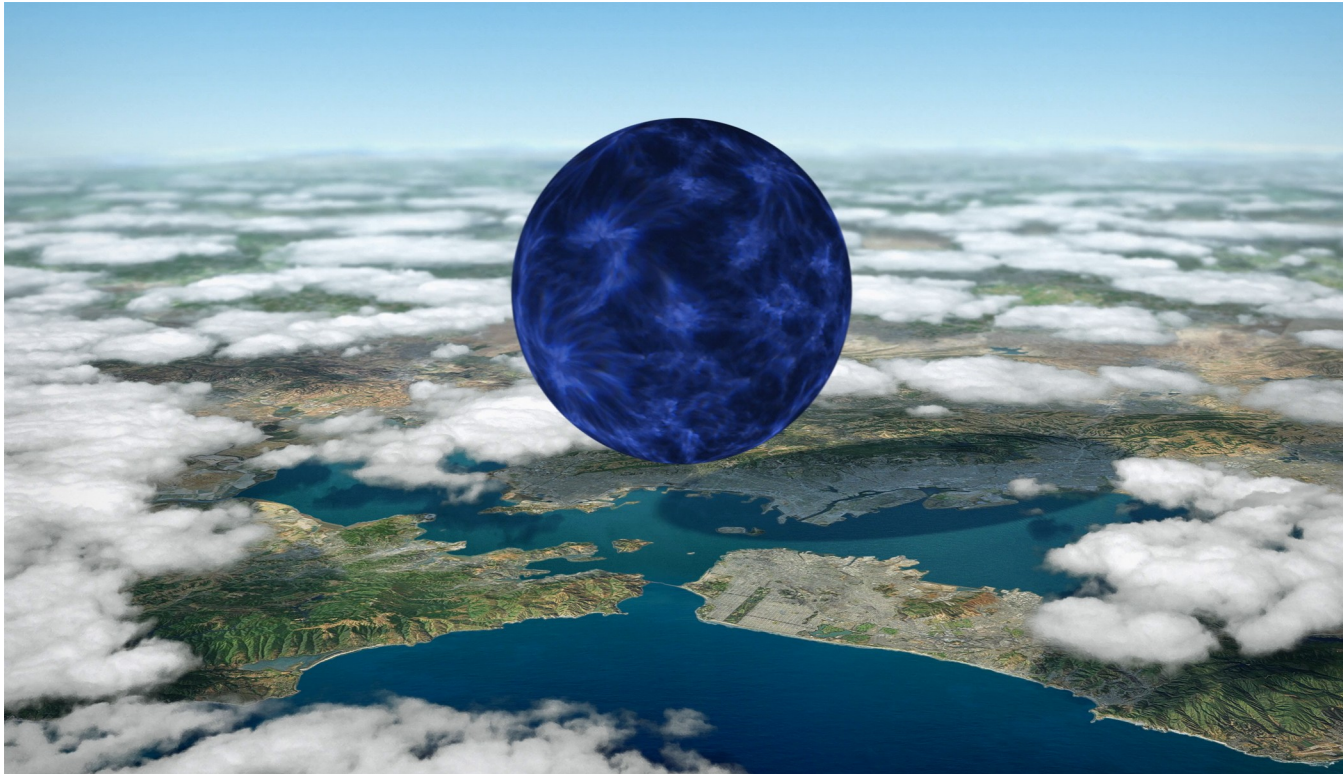
on behalf of the

NICER Collaboration





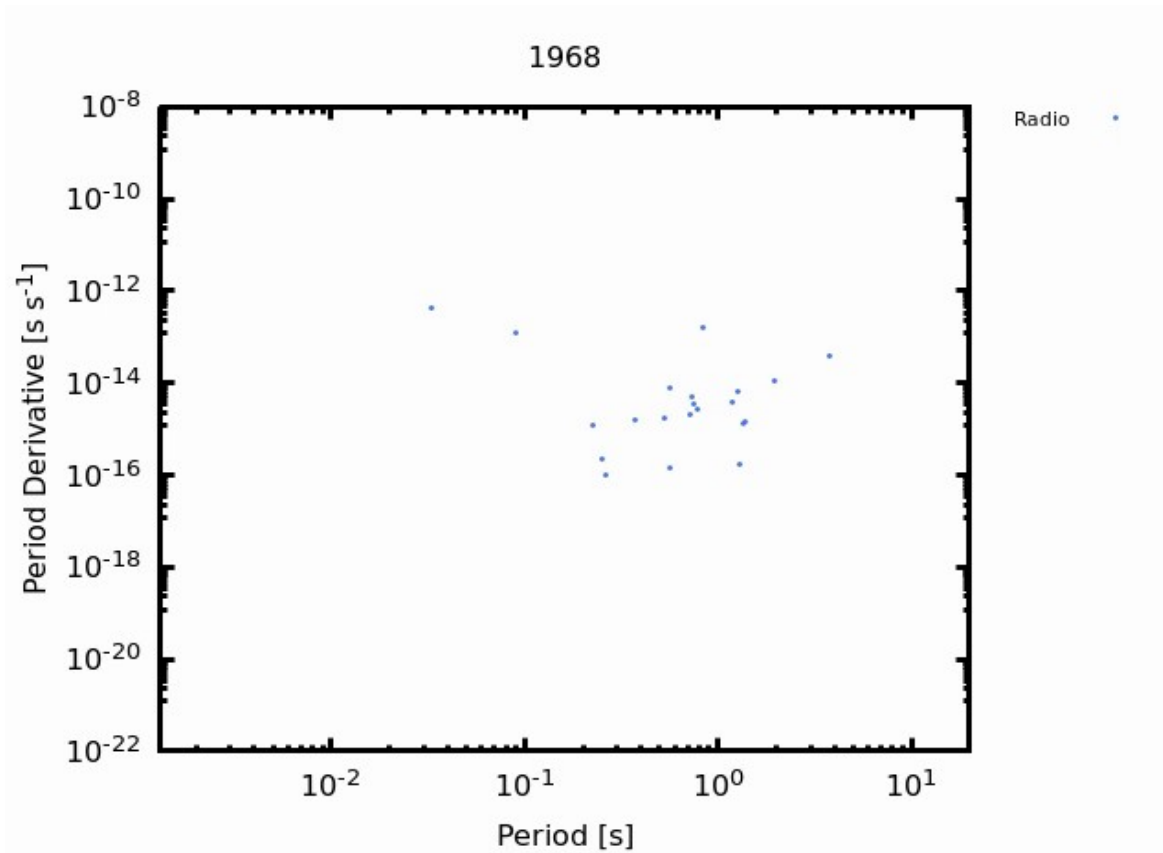
The neutron stars phenomenon



Credit: NASA



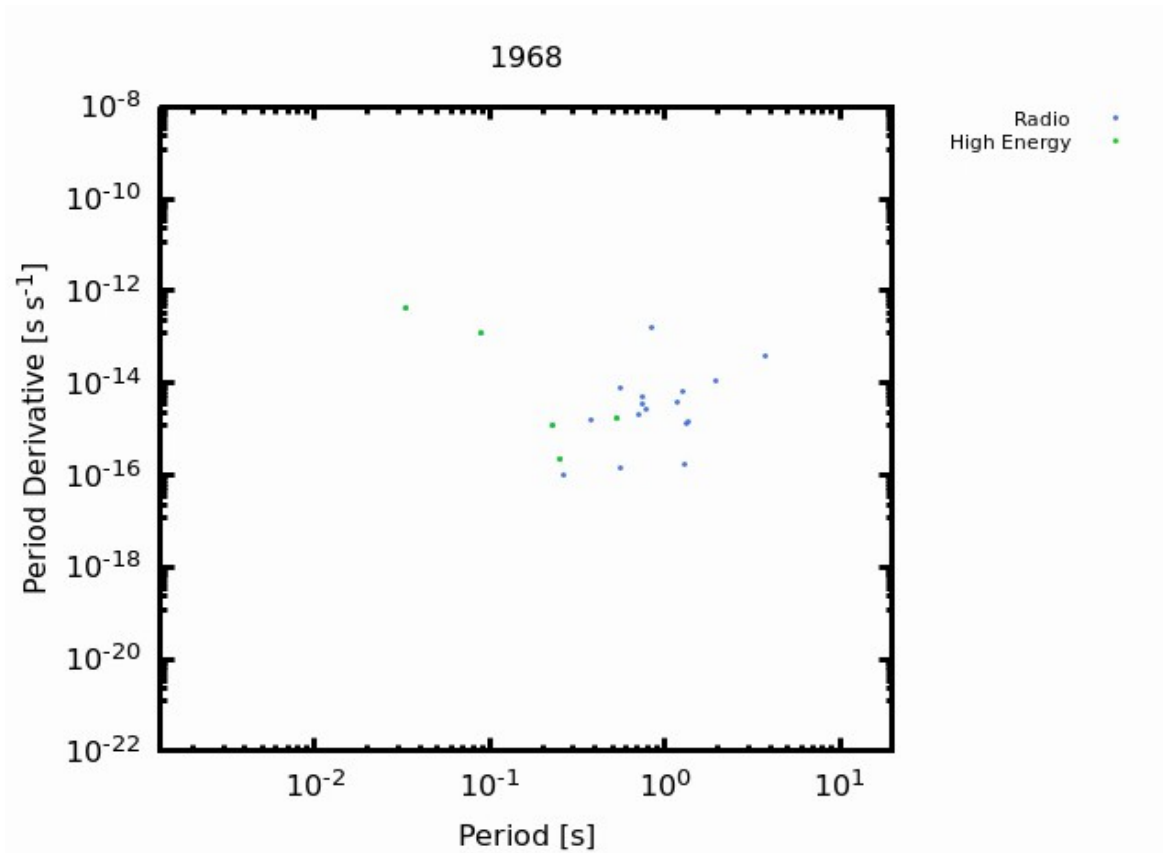
Why do we study the X-ray Universe?



ATNF Pulsar Catalog (Manchester et al. 1995), version 1.50.



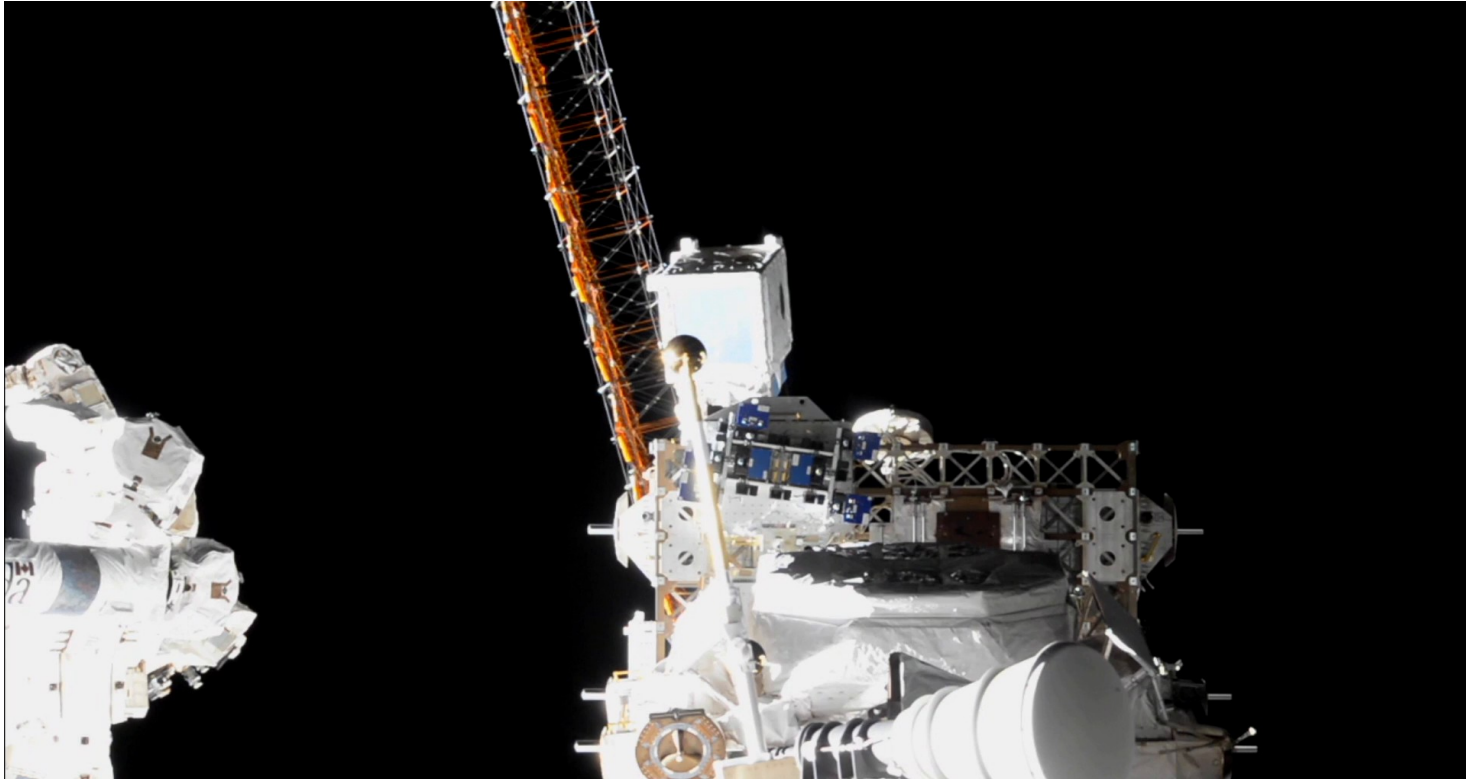
Why do we study the X-ray Universe?



ATNF Pulsar Catalog (Manchester et al. 1995), version 1.50.



NICER in operation on ISS



Credit: NASA



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NICER Launch: June 3, 2017

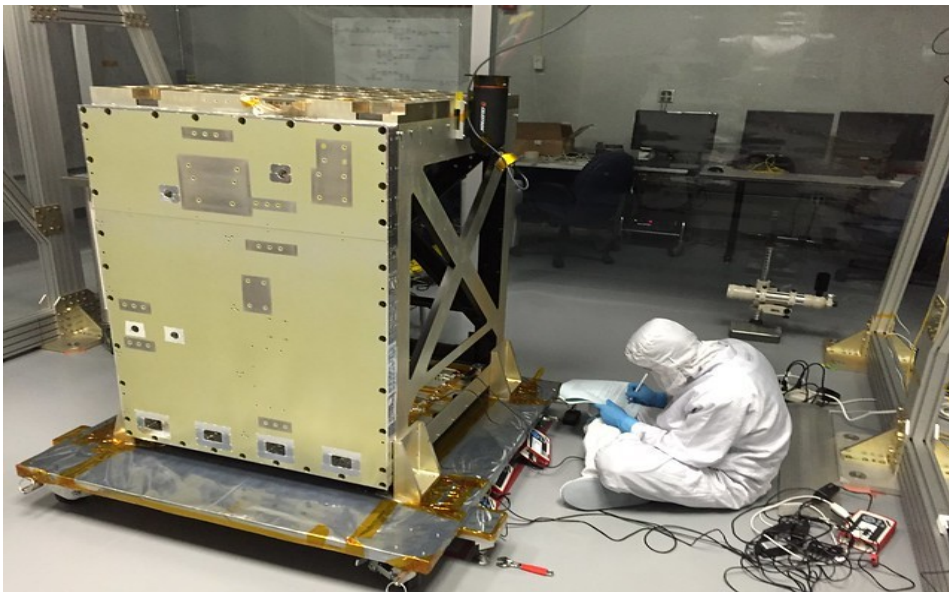
X-ray instrument mounted on ISS

sensitivity range: 0.2 - 12 keV

peak collecting area: 1900 cm² (1.5 keV)

launch: June 3, 2017

science operations: July 17, 2017



Credit: NASA



NICER Launch: June 3, 2017



Credit: NASA)

X-ray instrument mounted on ISS

sensitivity range: 0.2 - 12 keV

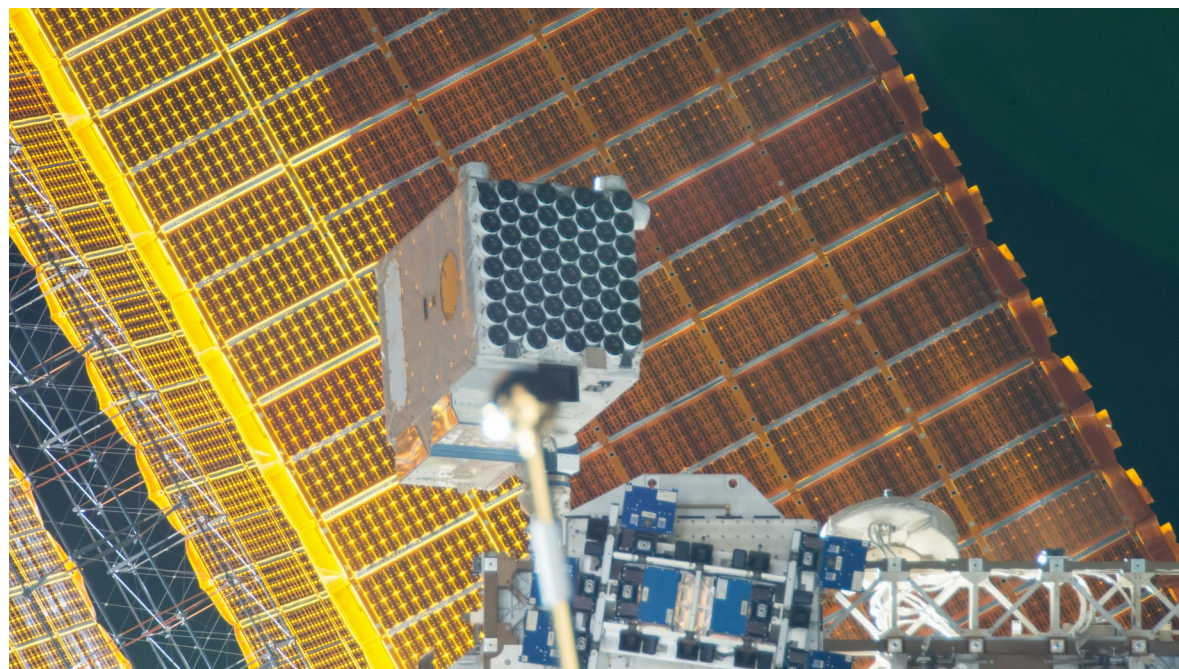
peak collecting area: 1900 cm² (1.5 keV)

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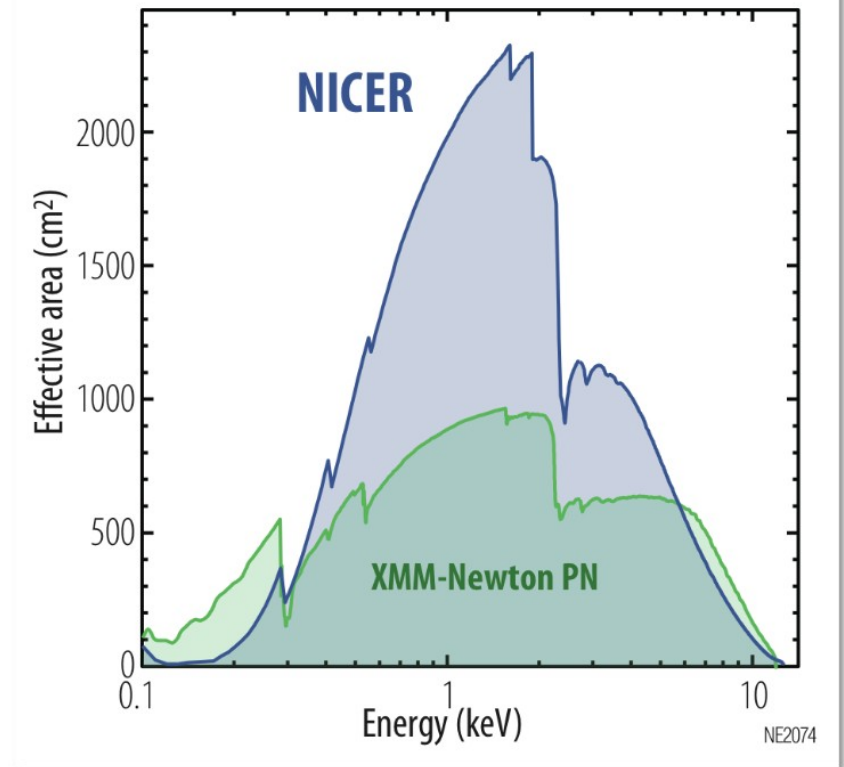
science operations: July 17, 2017



How NICER works (in a nutshell)



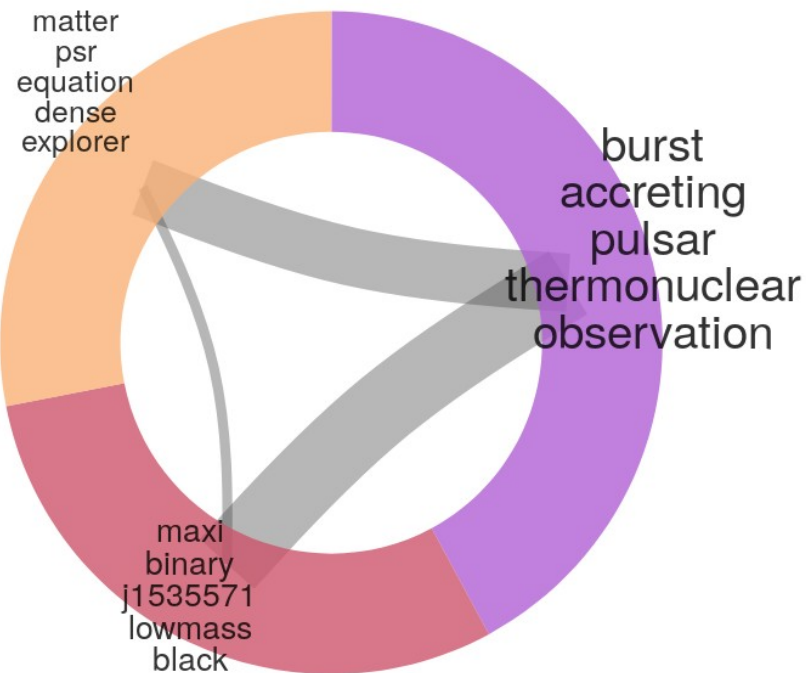
Credit: NASA



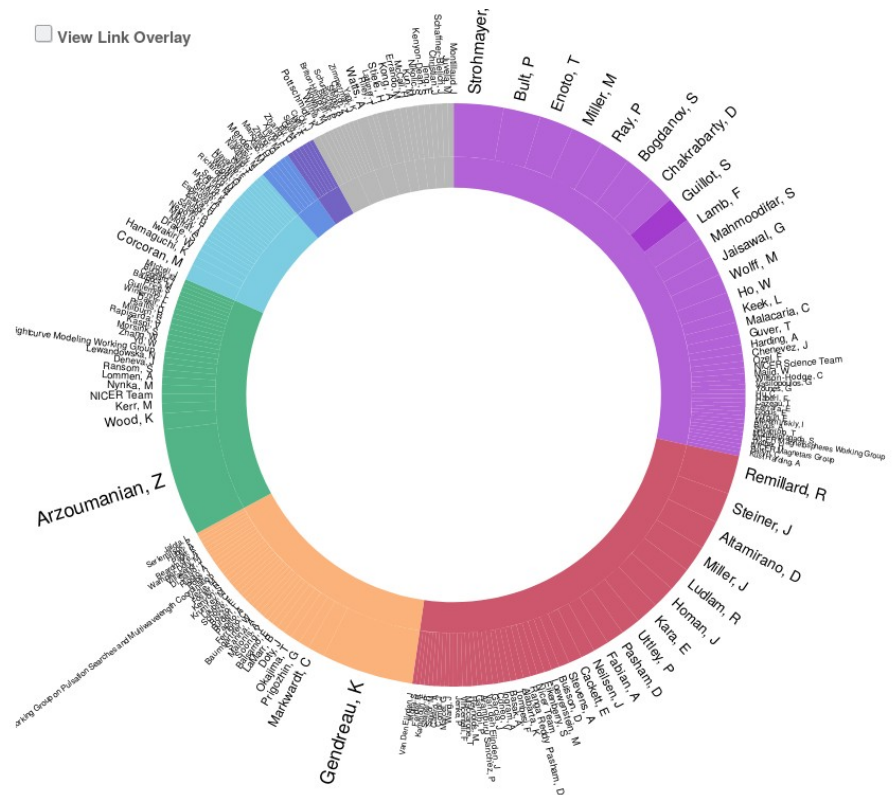
Credit: K. Gendreau



What happened since then?



Credit: ADS



Referred papers: 65 (Science Team: 57; Others: 8) ; ATels: 70



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NICER Timing Group Studies

THE ASTROPHYSICAL JOURNAL, 874:160 (13pp), 2019 April 1

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<https://doi.org/10.3847/1538-4357/ab0966>



CrossMark

High-precision X-Ray Timing of Three Millisecond Pulsars with *NICER*: Stability Estimates and Comparison with Radio

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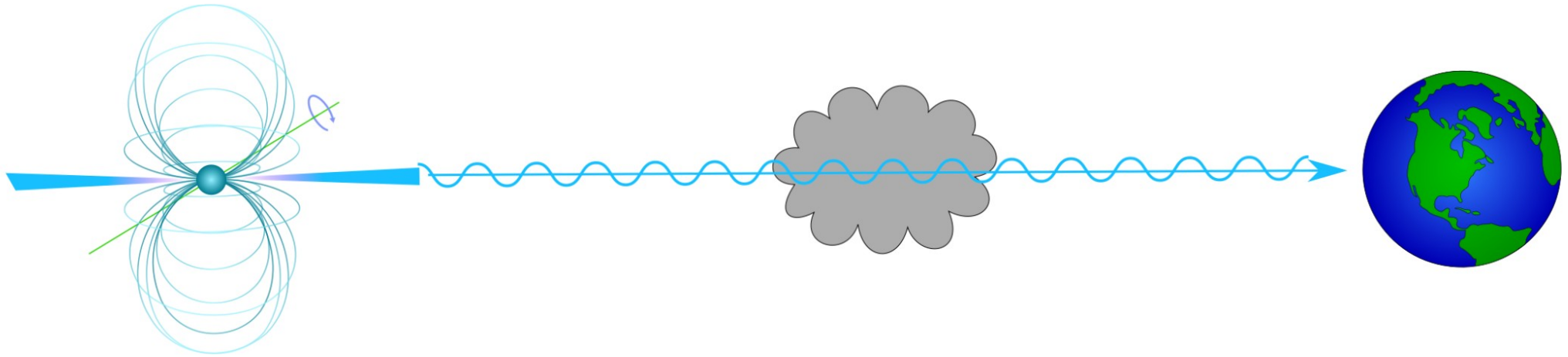
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Deneva et al. (2019)





NICER Timing Group Studies



$$\Delta t = \mathcal{D} \cdot \frac{DM}{f^2}$$

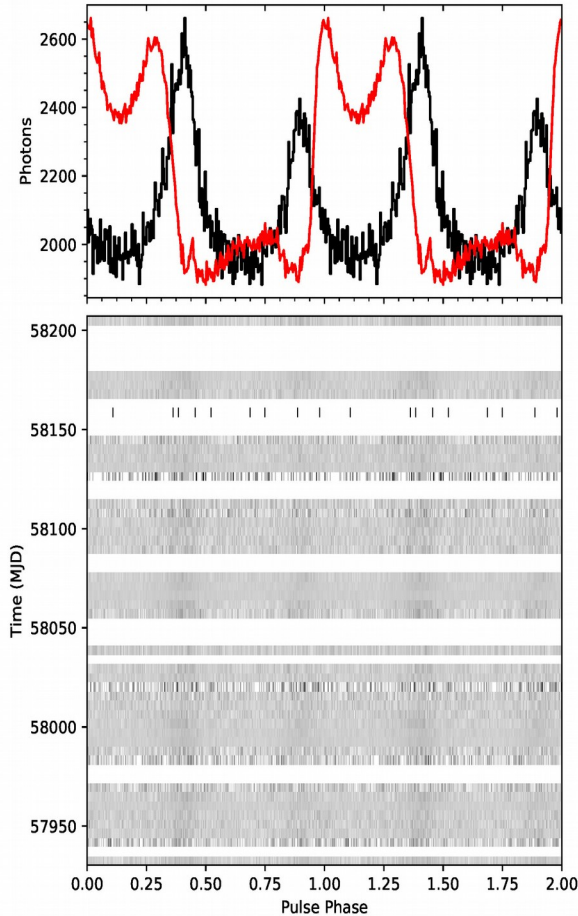
NICER data: taken at infinite frequencies

=> immune to ISM influence!

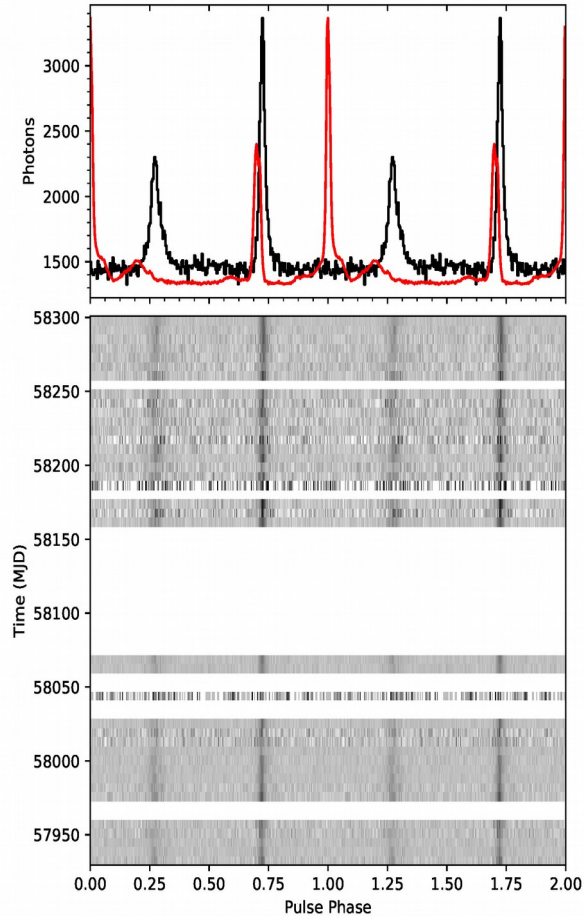




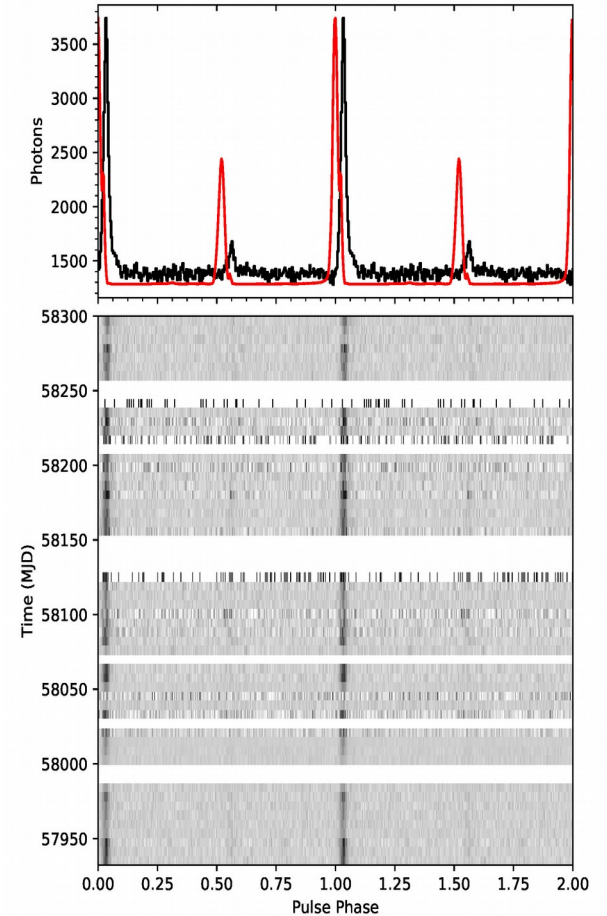
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PSR J0218+4232
(0.80 – 6.20 keV)



PSR B1821-24
(1.0 – 5.50 keV)



PSR B1937+21
(1.15 – 5.55 keV)

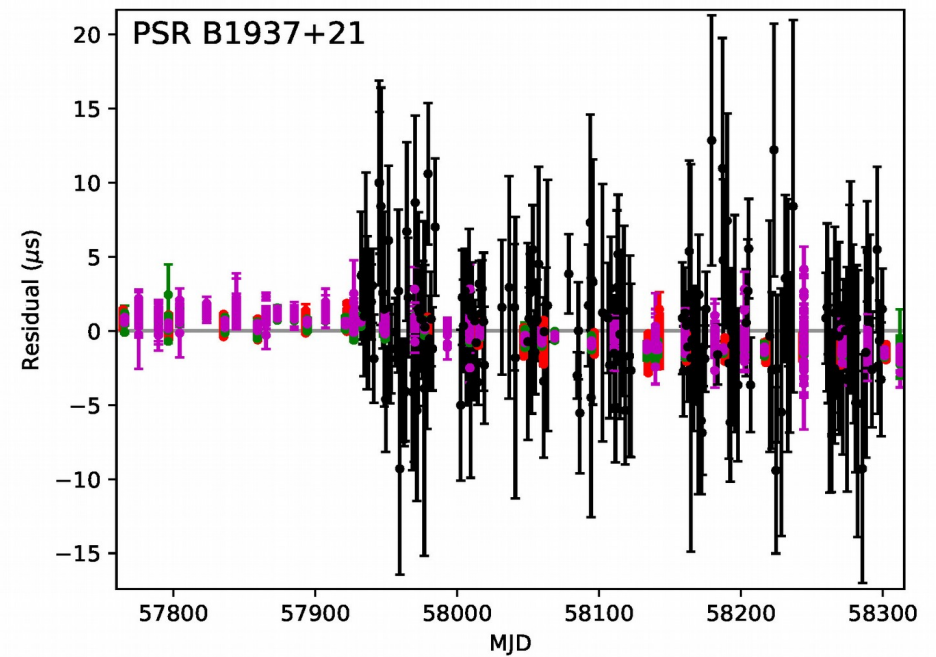
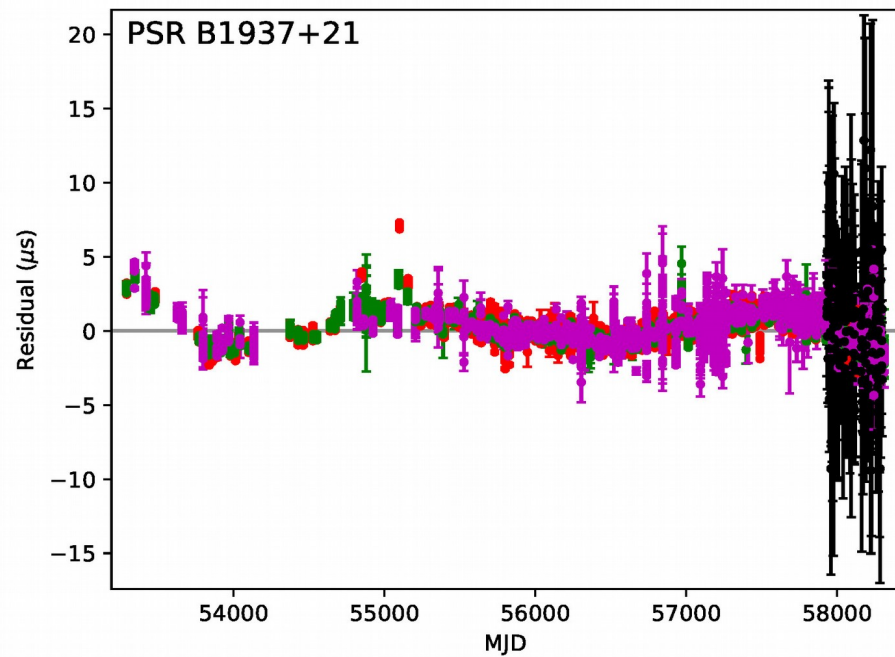
Deneva et al. (2019)



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Deneva et al. (2019)



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DRAFT VERSION FEBRUARY 3, 2020

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A NICER VIEW OF SPECTRAL AND PROFILE EVOLUTION FOR THREE X-RAY EMITTING MILLISECOND PULSARS

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Rowan et al. (2020)



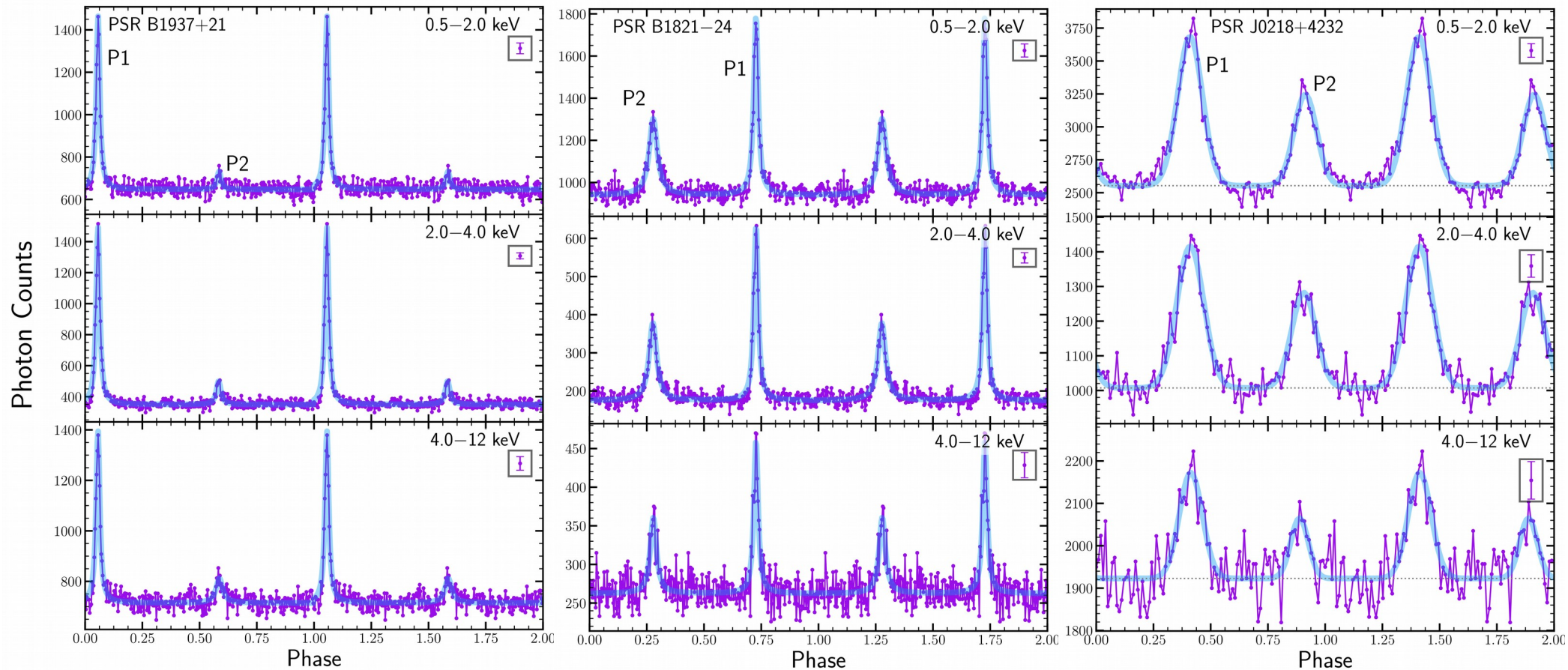
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2 years of NICER data



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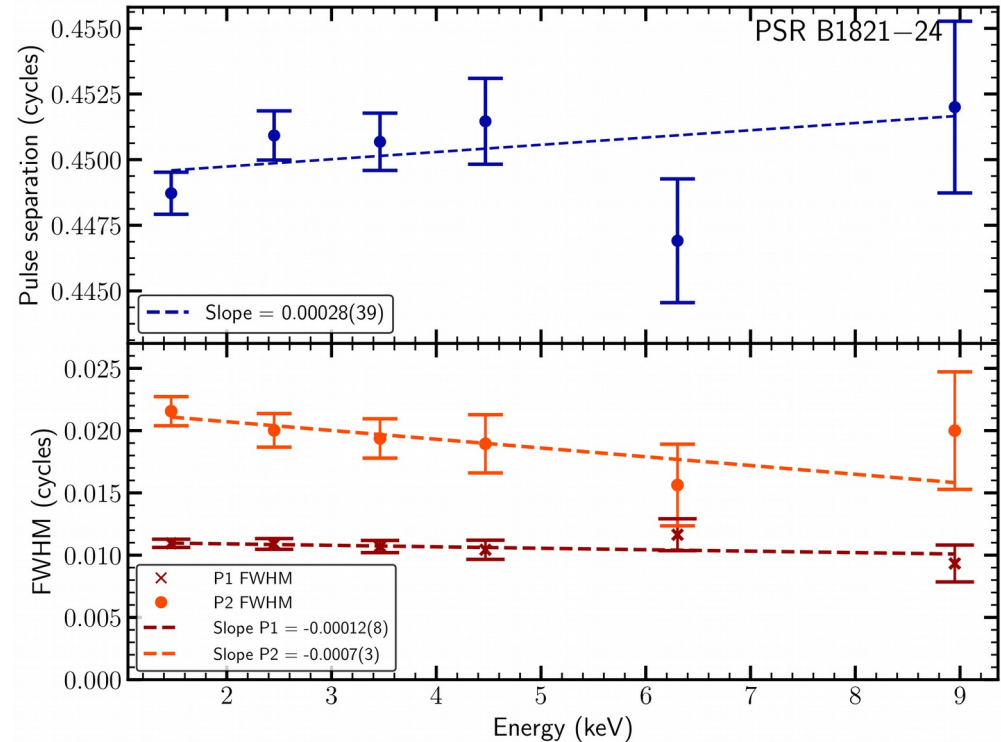
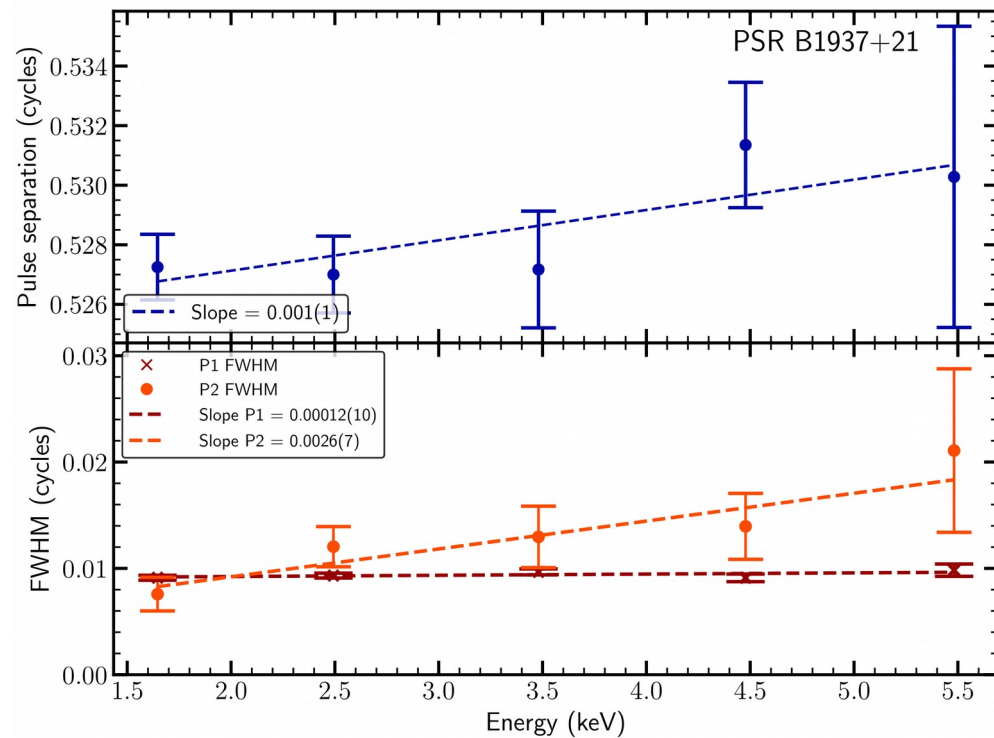
Rowan et al. (2020)





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Evolution of Pulse Separation & FWHM



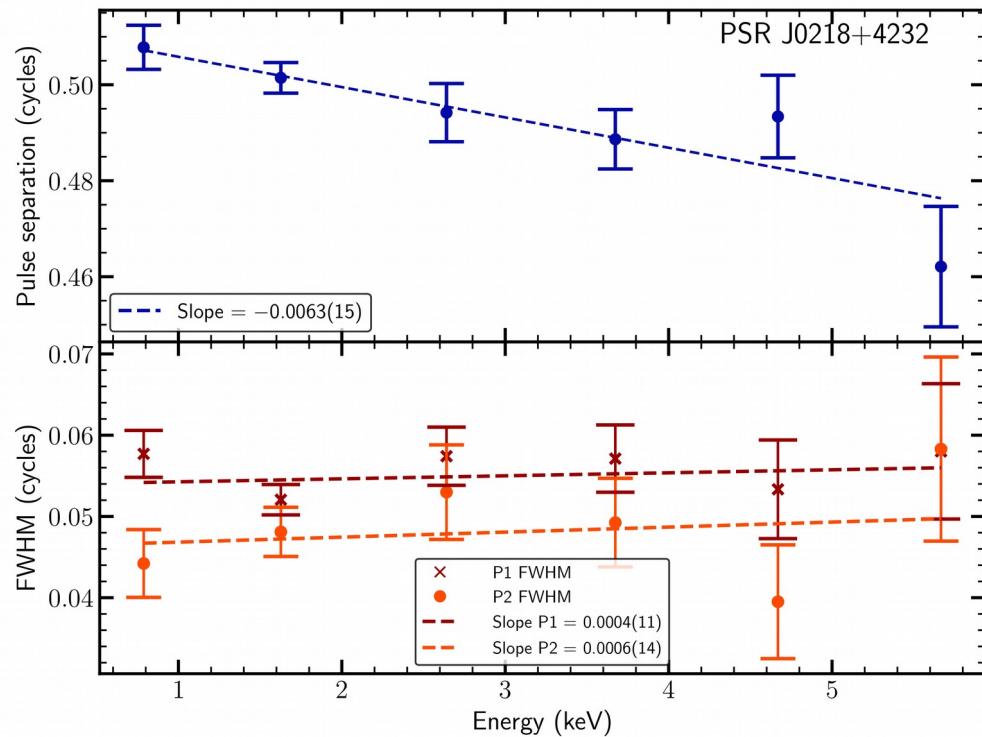
Rowan et al. (2020)





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Evolution of Pulse Separation & FWHM



Results:

J0218: pulse component separation decreases with increasing energy (> 3 sigma confidence)



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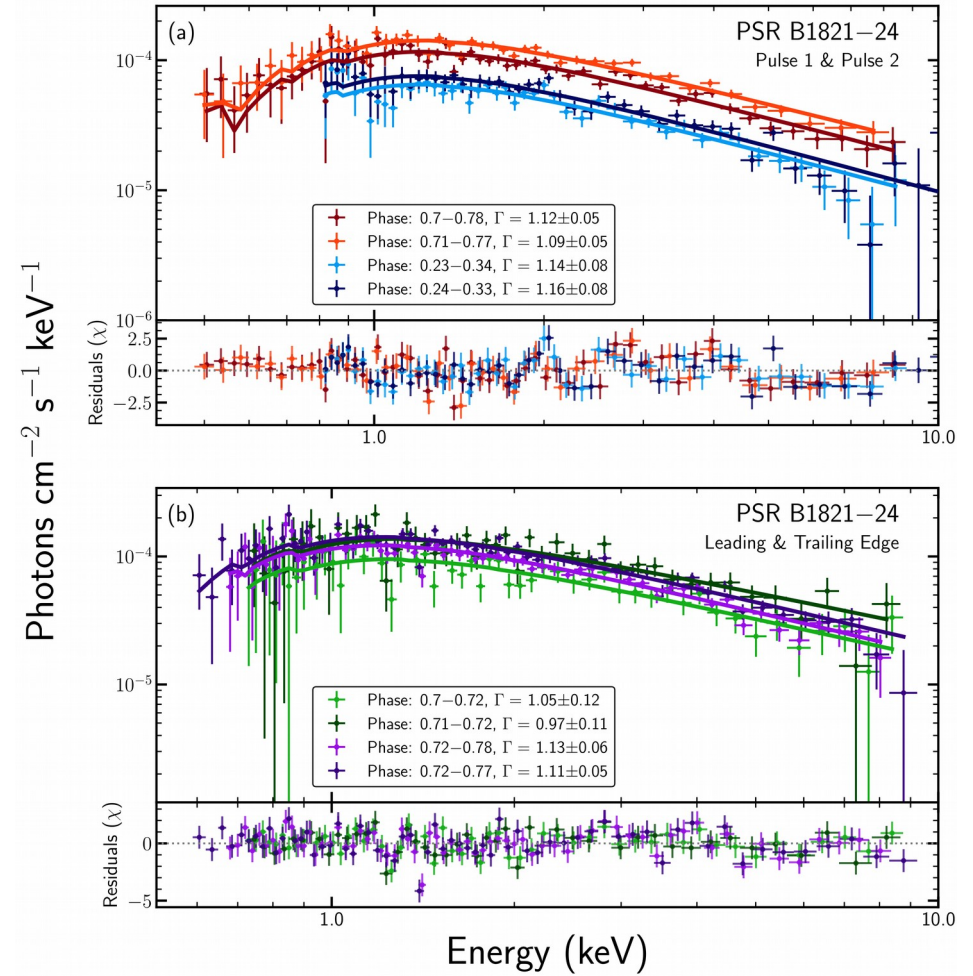
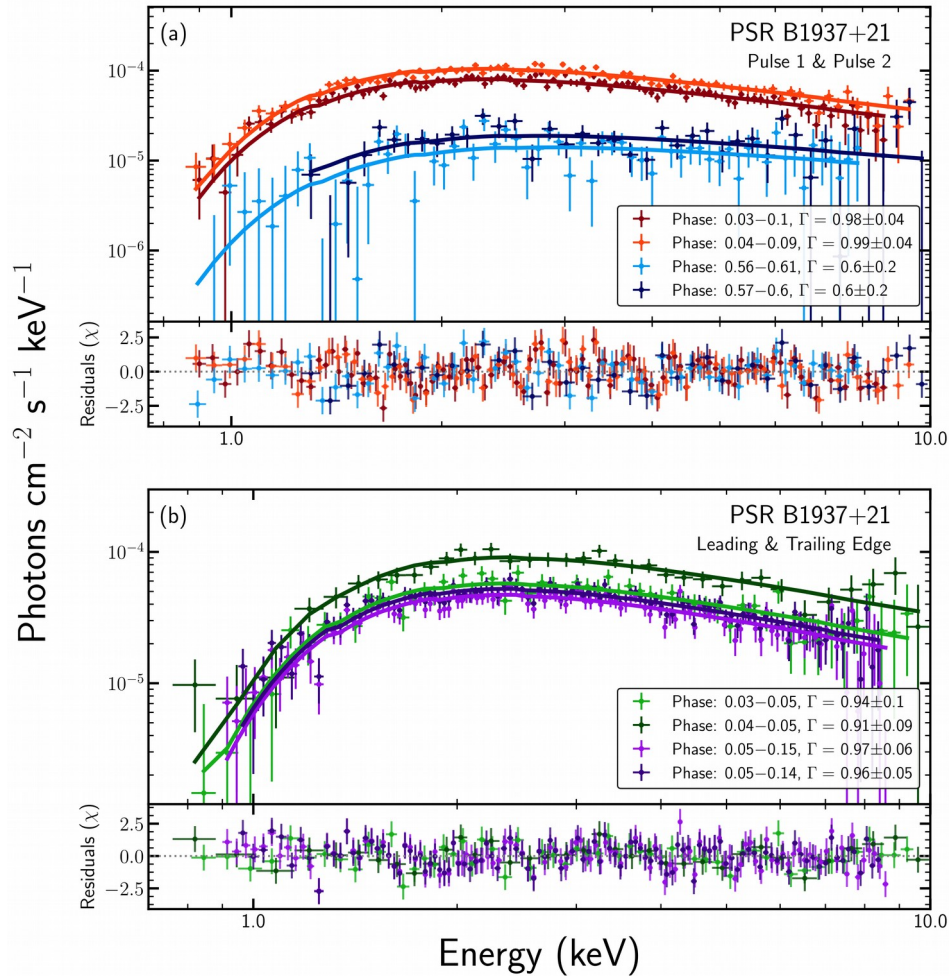
Rowan et al. (2020)





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Phase-resolved spectra



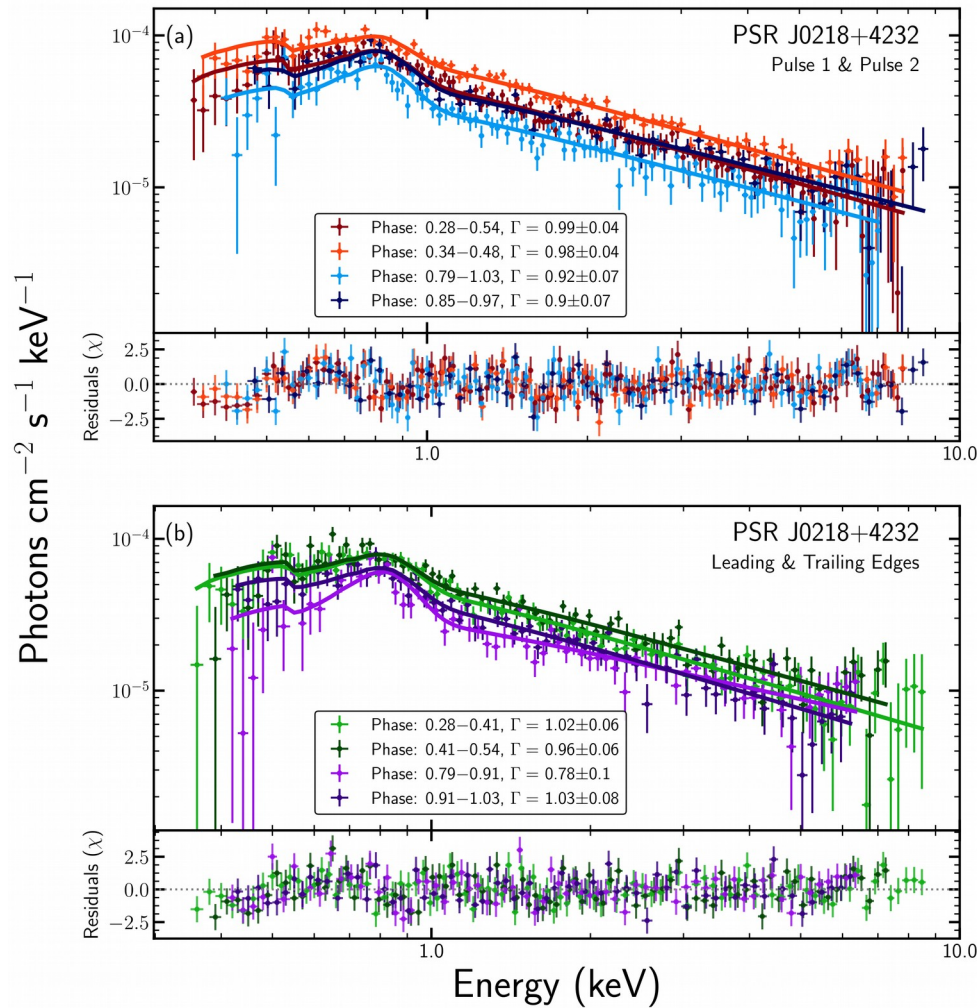
Rowan et al. (2020)





NICER Timing Group Studies

Phase-resolved spectra



Results:

- updated model parameters: single single absorbed power-law model
- no evidence of additional black body emission component (B1937 & B1821)
- J0218: additional component at energies $< 1\text{keV}$
- B1937: different P1 & P2 emission photon indices (> 2 sigma level)



Rowan et al. (2020)





NICER Lightcurve Modeling Group

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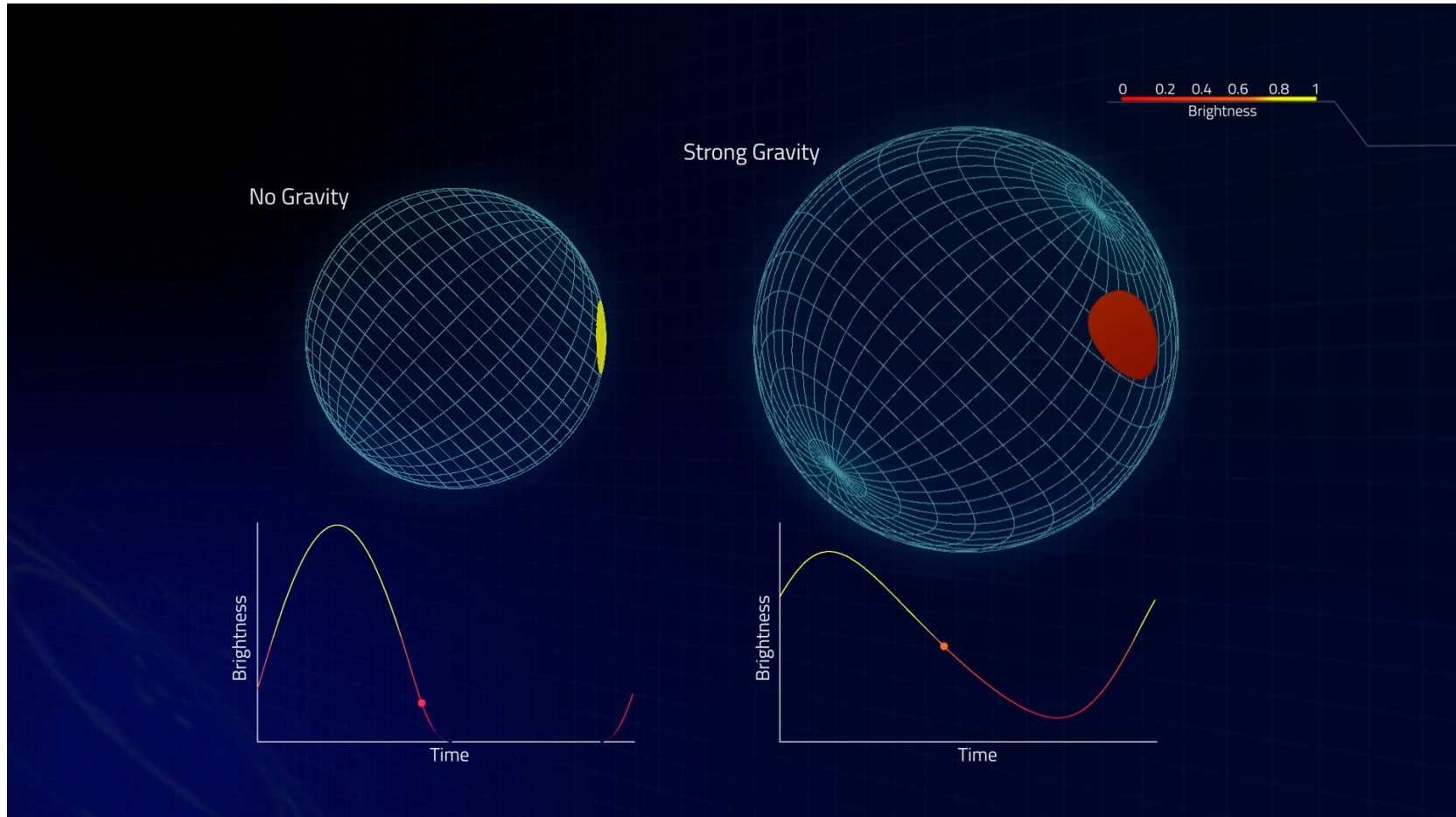


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Mass-radius Relation



Credit: Morsink/Moir/Arzoumanian/NASA GSFC



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Recent results

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CONSTRAINING THE NEUTRON STAR MASS-RADIUS RELATION AND DENSE MATTER EQUATION OF STATE WITH *NICER*. I. THE MILLISECOND PULSAR X-RAY DATA SET

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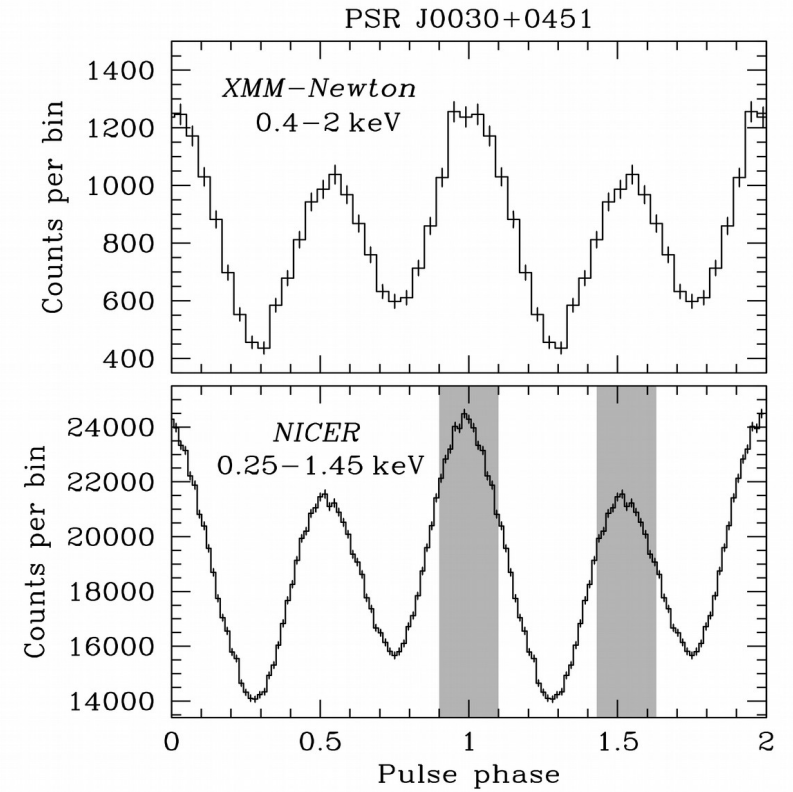
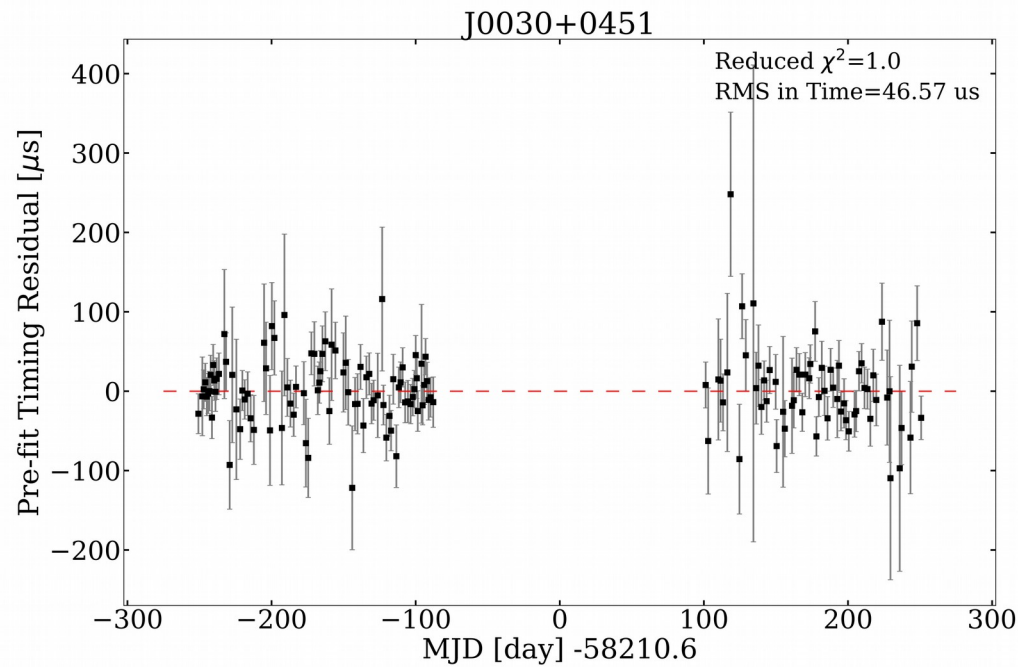
arXiv:1912.05706
Bogdanov et al. (2019)



o-ph.HE] 12 Dec 2019



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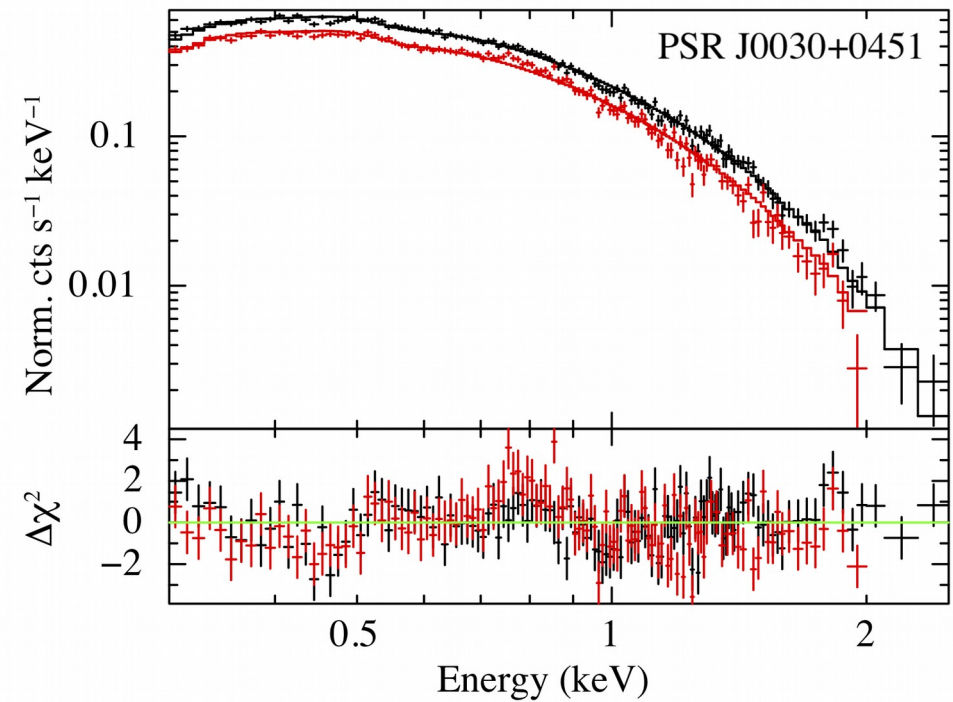
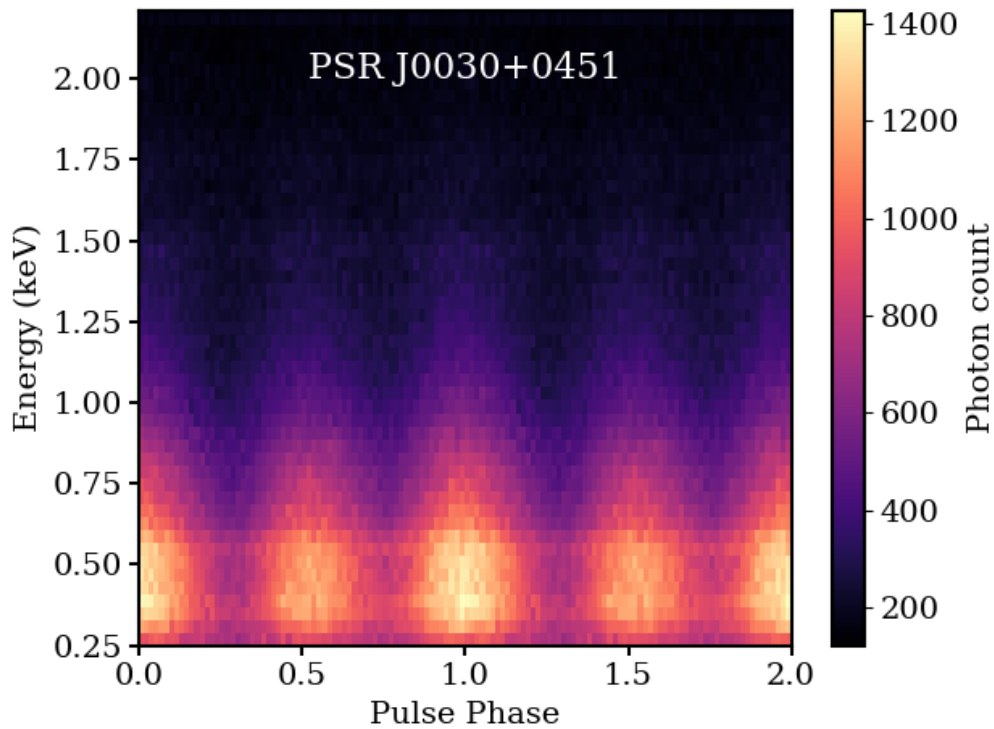
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arXiv:1912.05707
Bogdanov et al. (2019)





Recent results





Recent results

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CONSTRAINING THE NEUTRON STAR MASS-RADIUS RELATION AND DENSE MATTER EQUATION OF STATE WITH NICER. II. EMISSION FROM HOT SPOTS ON A RAPIDLY ROTATING NEUTRON STAR

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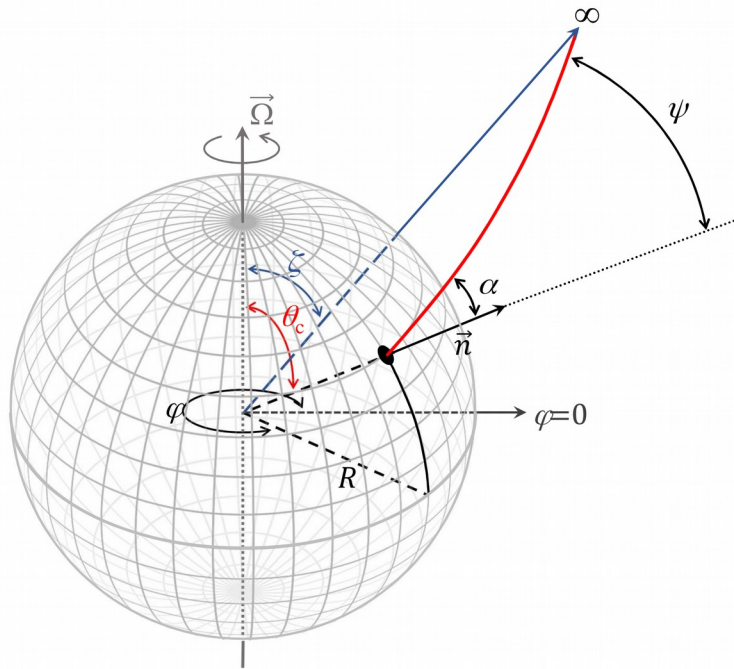
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arXiv:1912.05707
Bogdanov et al. (2019b)





Recent results



Verification tests:

- Schwarzschild + Doppler approximations
 - Oblate Schwarzschild approximations
 - comparison with numerical calculations
- => Good agreement between code outputs!



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arXiv:1912.05707
Bogdanov et al. (2019b)





Recent results

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A NICER VIEW OF PSR J0030+0451: MILLISECOND PULSAR PARAMETER ESTIMATION

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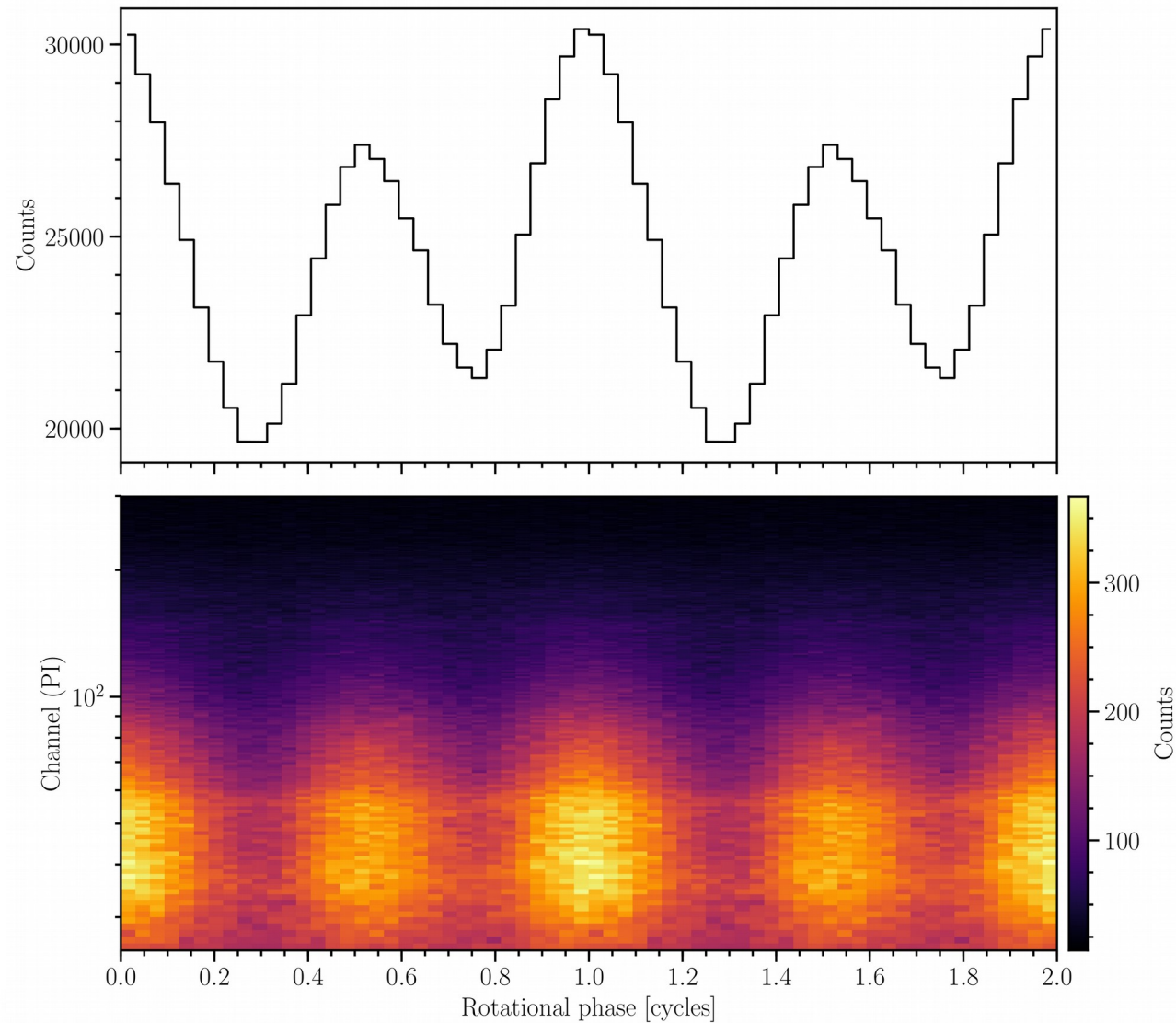
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arXiv:1912.05702
Riley et al. (2019)





Recent results



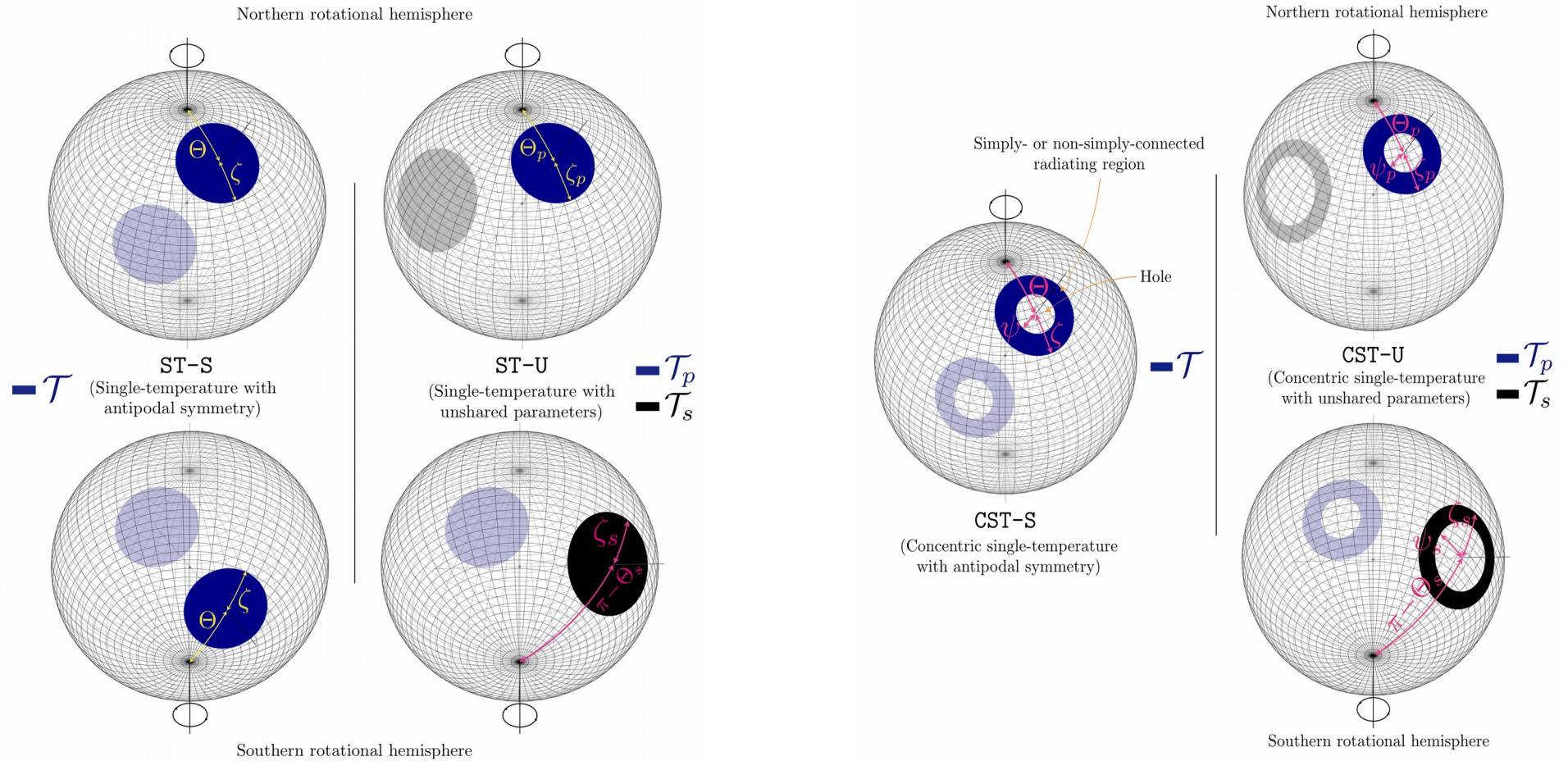
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arXiv:1912.05702
Riley et al. (2019)



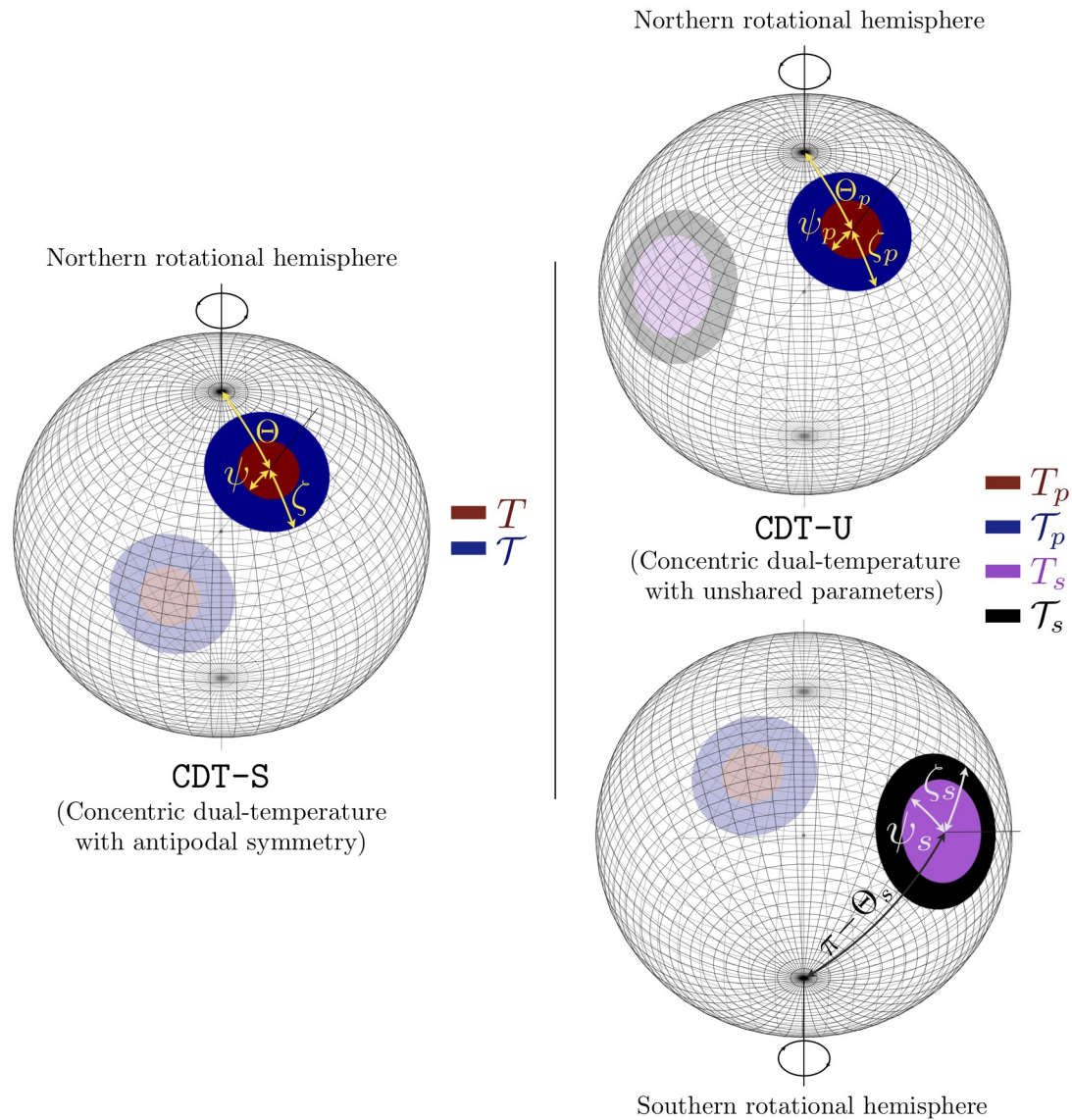


Recent results





Recent results





Recent results

Summary of results:

- Bayesian parameter estimation of mass & equatorial radius

=> **mass** ~ **1.34** M_{Sun}

=> **radius** ~ **12.71** km

- in favor: models with hot spots in same hemisphere

=> more parameters needed for successful description!

- disfavored: models with simply connected single temperature hot spots





Summary

- **NICER science operations ongoing since July 2017**
- **lots of interesting science projects published already**
=> https://heasarc.gsfc.nasa.gov/docs/nicer/nicer_results.html

NICER Precision Timing Group:

- **1 year of timing results published!**
- **2 year of X-ray pulsar data published**
=> **profile evolution paper**

NICER Light curve Modeling Group:

- **several new results published**

