The Variable X-ray Emission of PSR B0943+10

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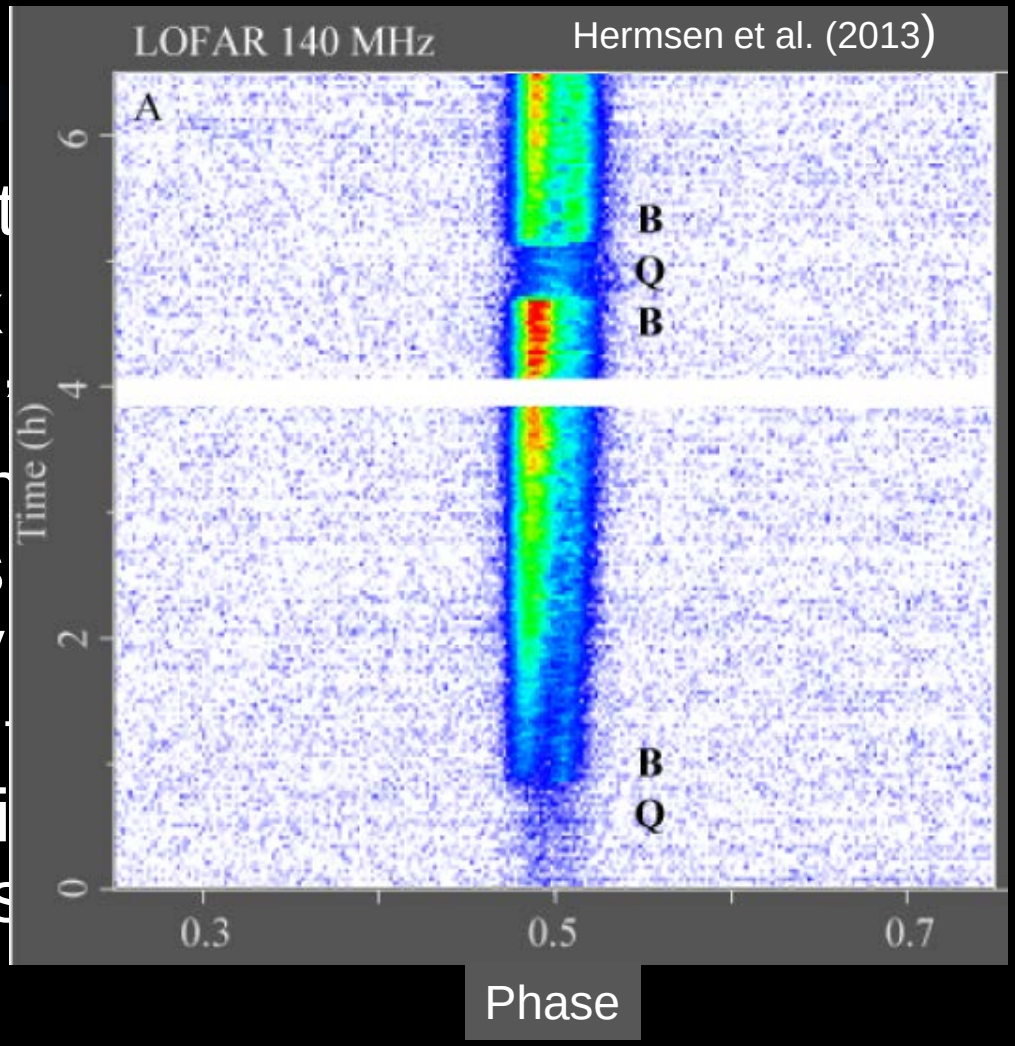
PSR B0943+10

- Old (≈ 5 Myr), rotat
- P = 1.1 s, Ṗ = 3.5x
- A “mode-switching alternates between (quiescent) modes 1984; Rankin & Suley
- X-rays detected wi Pavlov 2005): statisti and timing analysis



XMM-Newton Observations

- PSR B0943+10 was observed again with *XMM* late in 2011
- Simultaneous radio coverage @ 320 MHz (GMRT) and 140 MHz (LOFAR)
- Net exposure time ~ 50 ks for each mode in the MOS's

The X-ray emission of PSR B0943+10 changes according to its radio state

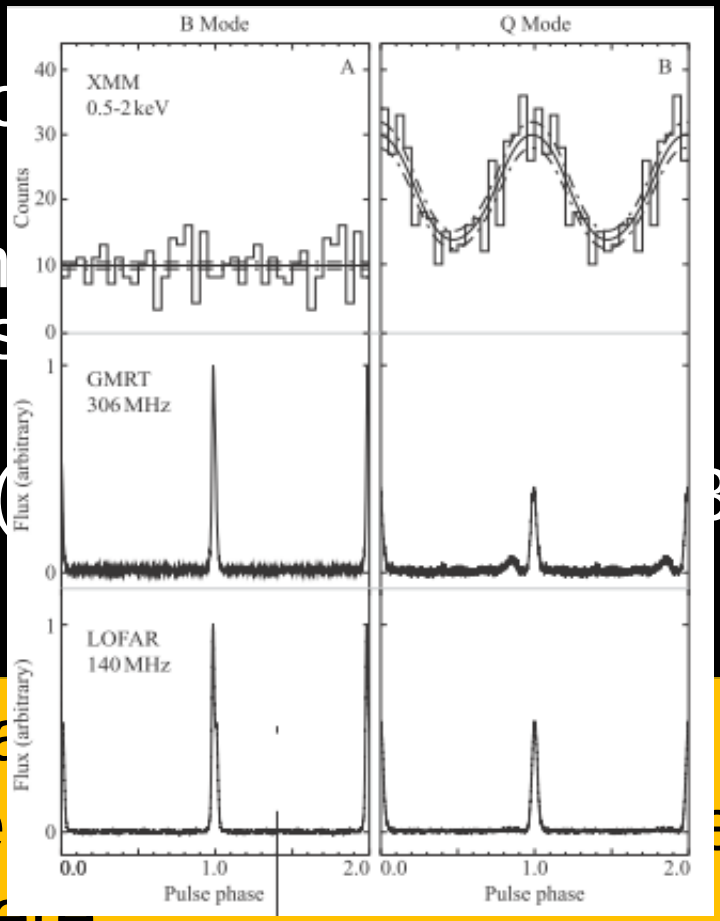
The pulsar is brighter in the (radio fainter) Q mode by a factor of ~ 2 (Hermsen et al. 2013)

Quite unexpected ! Rotation-powered NSs believed to be steady X-ray emitters

Spectral and Timing Analysis

- X-ray pulsations detec
  mode
- Spectrum is BB+PL in
  component 100% puls
  ~ 2.6)
- In the B mode only a (
  is present

Hemsen et al. (2013)



According to Hermsen et a
changes requires a sudde
of the pulsar magnetosphere

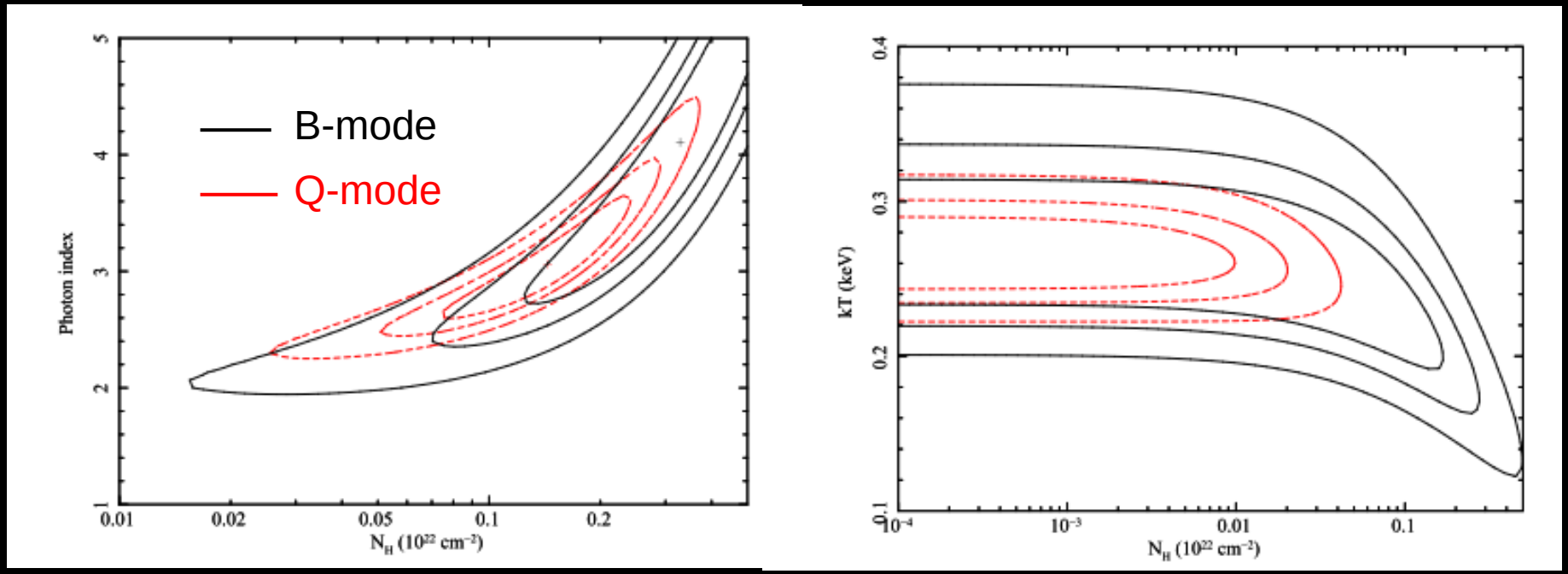
Open issues:

- PSR B0943+10 is a nearly aligned rotator seen pole-on ($\chi \sim 15^{o}$, $\xi \sim 0^{o}$; Deshpande & Rankin 2001): one cap always visible, PF ≤ 2%
- What is producing the 100% modulation of the BB component ? Why is it suppressed in the B mode ?
- Phase- (and radio-state) dependent absorption/scattering in the

Beaming effects in a magnetized atmosphere may produce a large pulsed fraction in the thermal component; both B- and Q-mode spectra might be reproduced invoking a (largely) off-centred dipole (Storch et al. 2014)

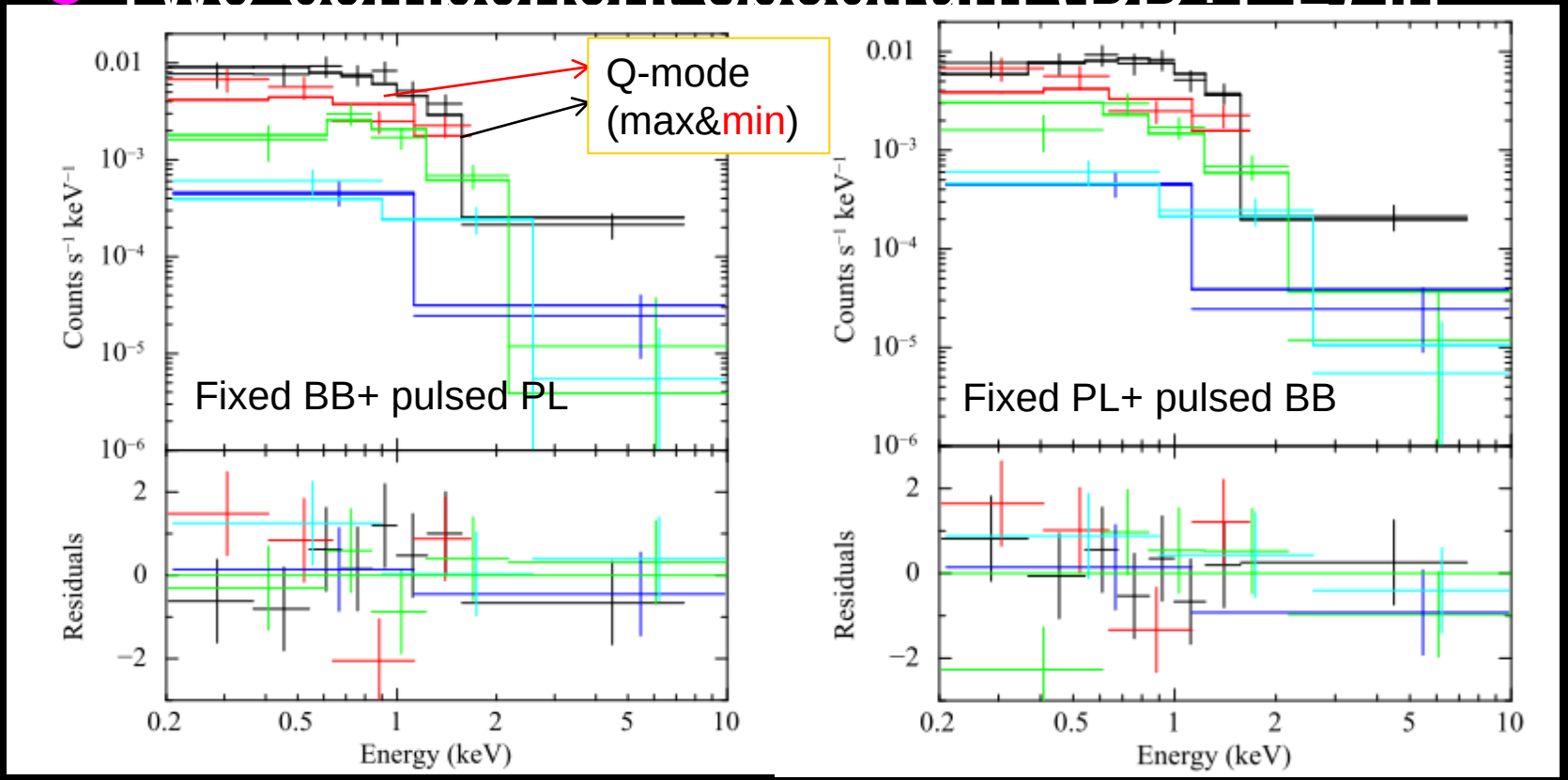
A Fresh Look at XMM Data - I

- A reanalysis of *XMM* data confirms the X-ray flux dependence on radio state (Mereghetti et al. 2013)



A Fresh Look to XMM Data - II

- Two-component spectrum (BB+PL) in

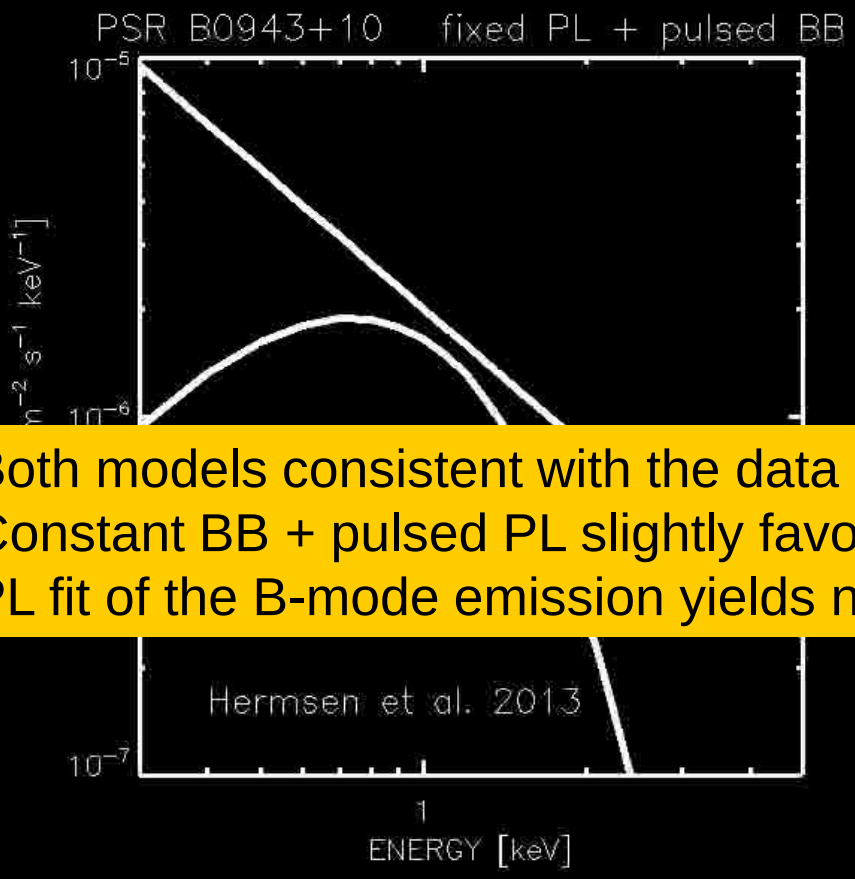


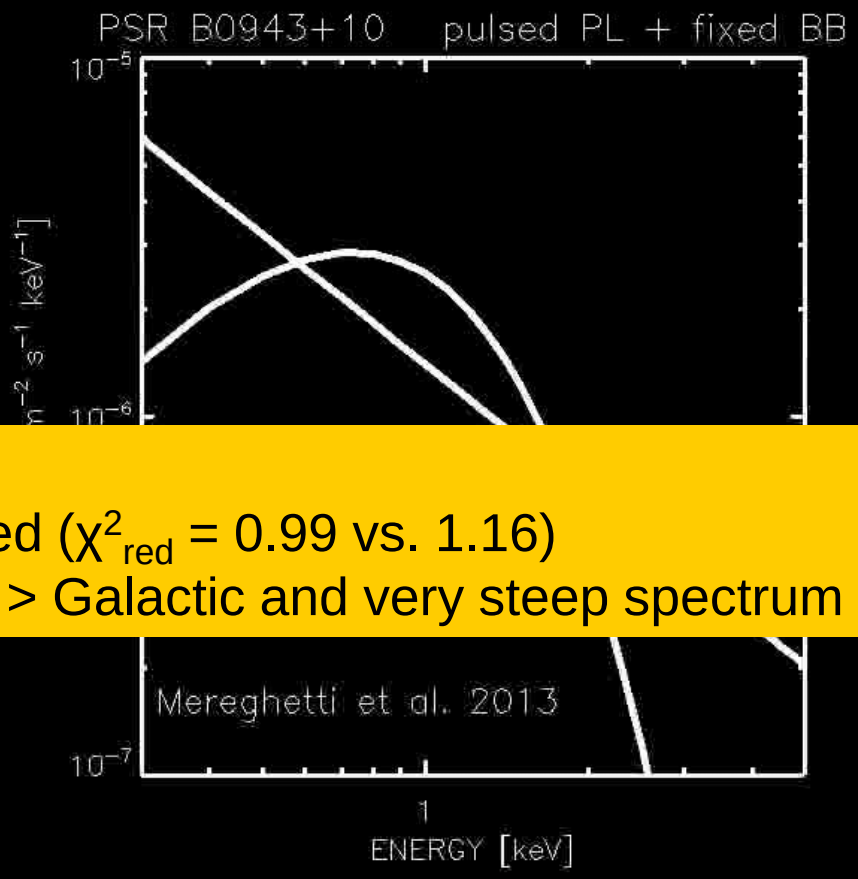
Hermsen et al. (2013)

B-state
PL

Mereghetti et al. (2013)

B-state
BB





Both models consistent with the data
Constant BB + pulsed PL slightly favored (χ^2_{red} = 0.99 vs. 1.16)
PL fit of the B-mode emission yields n_H > Galactic and very steep spectrum

More Than Meets the Eye ?

- Thermal emission from a small polar cap consistent with lack of pulsations in the B-mode

No need for dramatic magnetospheric rearrangements ?

Co-ordinate radio and X-ray observations for other mode-switching PSRs

PSR B1822-09 (talk by Wim Hermsen)

- Difference between B- and Q-mode possibly due to (slight) changes in the beaming direction/efficiency

More Is Coming...

- 400 ks *XMM* Large Program, split in 3-4 ~ one-day pointings; observations scheduled in October-D
- Simultaneous radio coverage with major telescopes (EPTA: 10 h/d, MWA: 5 h/d; Parkes, GBT & Areceibo: 3h/d)
- Longest uninterrupted monitoring of any PSR
- Approved *Chandra* pointing to assess possible PWN contribution to non-thermal emission

STAY TUNED