New optical/UV counterparts and SEDs of Isolated NS

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RX J1856...a puzzle!

- Featureless BB spectrum instead of harder than Wien tail or any spectral features (Burwitz et al 2001, 2003)

- Optical excess = 8 (Walter & Matthews 1997; van Kerkwijk & Kulkarni 2001) but Rayleigh-Jeans

- X-ray => Too small Radii

- Optical => too large Radii (Braje & Romani 2002)
Is RX J1856 special or do all INSs show similar behavior (Optical Excess, Rayleigh-Jeans spectrum)?

Could this behavior be explained?
Identifying counterparts

easy

HST photometry => very reliable
Identifying counterparts

easy

some-what
easy
Identifying counterparts

Mignani et al. 2009

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Identifying counterparts

Estimated proper motions => consistent with Motch et al. (2005, 2009)
• power law with index: 4.2 - 2.5
• opt excess: 5 - 50
• power law might be too simplistic => lines/wings (Pavlov's talk PSR0656)
Different emission regions:
Pulsed fraction v/s Optical Excess

Braje & Romani 2002, Kaplan et al. 2011

* small hotspot => large pulsed fraction and optical excess: No strong correlation
Different emission regions:
Opt/UV as separate BBs

Braje & Romani 2002, Kaplan et al. 2011

Dotted lines: unabsorbed BB
Different emission regions:
Pulsed fraction vs Optical Excess

Braje & Romani 2002, Kaplan et al. 2011

* small Hotspot => large pulsed fraction and optical excess: No strong correlation

* Separate BB: Unreasonably high radii for NS

* spectral-index vs kT: Hotter objects have smaller spectral index
Magnetospheric emission: non-thermal Lum-X v/s Edot

* NT Lum-X of INSs are close to 100% of Edot. Comparatively, radio pulsars have NT Lum-X = $10^{-3} \times$ Edot (Becker & Trumper 1997)
Magnetospheric emission: Lum-opt v/s Edot

- NT Lum-X of INSs are close to 100% of Edot. Comparatively, radio pulsars have NT Lum-X = $10^{-3}$ x Edot (Becker & Trumper 1997)

- Lum-Opt of INSs are $>10^{-3}$ x Edot. Radio pulsars have Lum-Opt $<10^{-6}$ x Edot (Zalin & Pavlov 2004)
**Magnetospheric emission:**

**Optical Excess v/s Edot**

* NT Lum-X of INSs are close to 100% of Edot. Comparatively, radio pulsars have NT Lum-X = 10^{-3} x Edot (Becker & Trumper 1997)

* Lum-Opt of INSs are >10^{-3} x Edot. Radio pulsars have Lum-Opt <10^{-6} x Edot (Zalin & Pavlov 2004)

* If part of the optical emission is due to spin down => Optical Excess - Edot correlation : No such definitive correlation is seen
Magnetized Atmosphere models

- Magnetized atmosphere models (Ho et al. 2008) => Optical/UV excess may depend on $B$

- models: $B = 1-30 \times 10^{12}$ G, $kT = 20-400$ eV, partially ionised hydrogen

- Brightness differs from BB but Rayleigh-Jeans behavior stays

Wings of Proton-Cyclotron line can reproduce the spectral behavior of INSs partly => $B_{\text{model}} \ll B_{\text{timing}}$
Conclusions

- Counterparts of all seven INSs have been identified unambiguously.
- All INSs show optical excess.
- The “Excess” in some cases deviate significantly from the Rayleigh-Jeans regime.
- Explanations ranging from different emission regions to mechanisms considered. None seems sufficient.
- More observations required to clearly characterize the optical/uv excess.
Details & Back up slides
RCS models

- Resonant Cyclotron Scattering (Lyutikov & Gavriil 2006) => thermal photons matching cyclotron freq. of the NS magnetosphere undergo efficient repeated scatterings

- Photons are up-scattered => Thermal spectrum gets modified => produces BB+PL hard tail (see Rea et al. 2008)

- The model would retain Rayleigh-Jeans spectrum

- Would it produce optical/UV excess? (Also see Tong et al 2010, 2011)