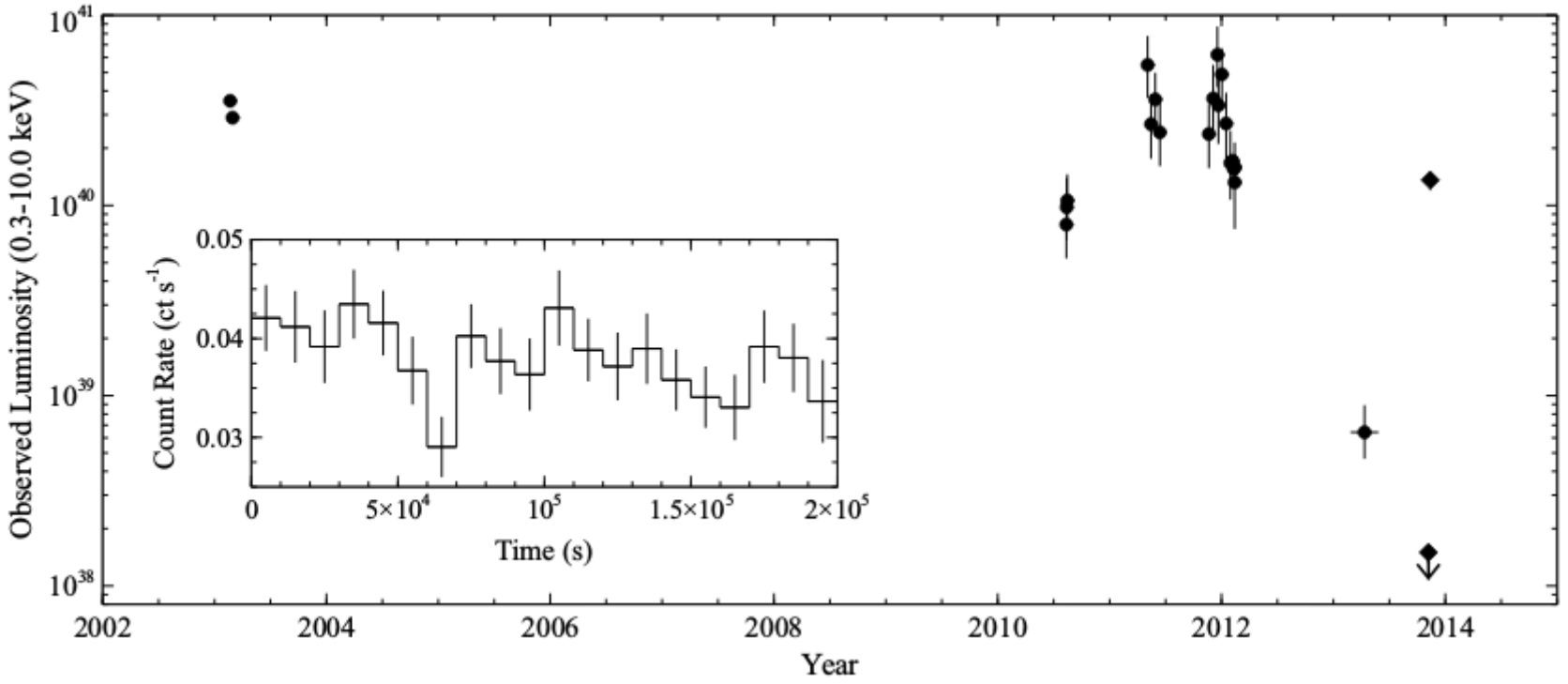
Do pulsating ULXs show radio pulsations during their low states?

Natalie Webb, Filippos Koliopanos
Institut de Recherche en Astrophysique et Planétologie (IRAP), Toulouse, France
Lucas Guillemot, Ismael Cognard
Laboratoire de Physique et Chimie de l'Environnement et de l'Espace, Orléans, France

X-ray variability of the pulsating ULXs

	M82 X-2	NGC 7793 P13	NGC 5907 ULX1
Max. Luminosity	2×10^{40} erg/s	6×10^{39} erg/s	$>10^{41}$ erg/s
Min. Luminosity	$<2.5\times10^{38}$ erg/s	$\sim4\times10^{37}$ erg/s	$<4\times10^{38}$ erg/s
References	Bachetti et al. 2014; Brightman et al. 2017; Dall'Osso et al. 2015	Fürst et al. 2016; Israel et al. 2017a	Israel et al. 2017b; Fürst et al. 2017; Walton et al. 2015

(Fürst 2017)



Walton et al. (2015) NGC 5907

Origin of 'bimodal' X-ray variability

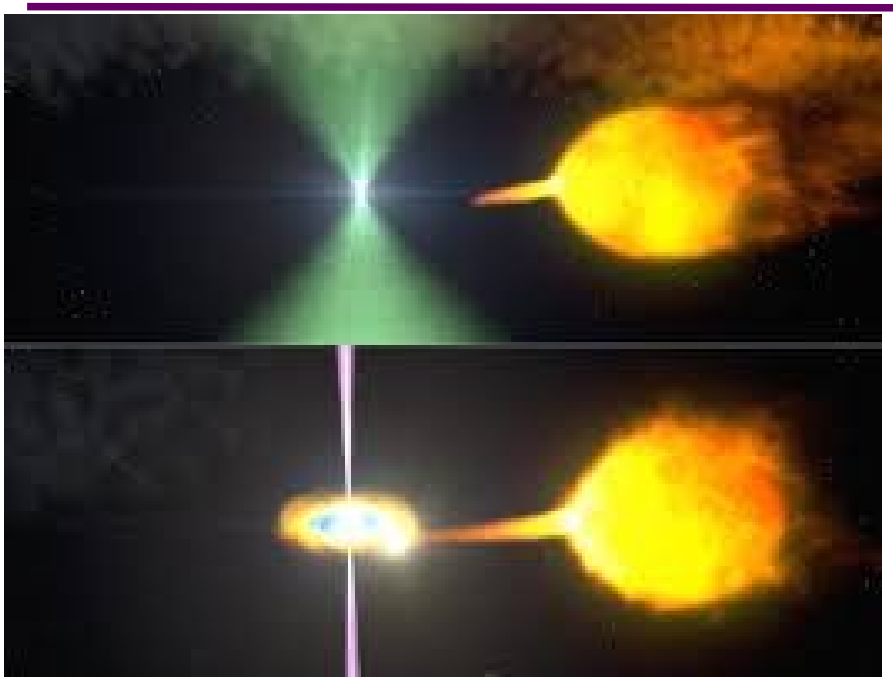
Low state : accretion reduced / « switched off » ?

What mechanism ?
- Propeller effect ? Lack of spectral softening may indicate not
- Precession
- Obscuration (e.g. by outer accretion disc e.g. Motch et al. 2014)
- Something else ?

Can we tell if accretion is stopped in pulsating ULXs ?
- does the neutron star stop spinning up ?
- does it start to spin down ?

Caveat, in very faint X-ray states, no X-ray emission detected with which to measure the pulse period !

X-ray variability of accreting millisecond pulsars

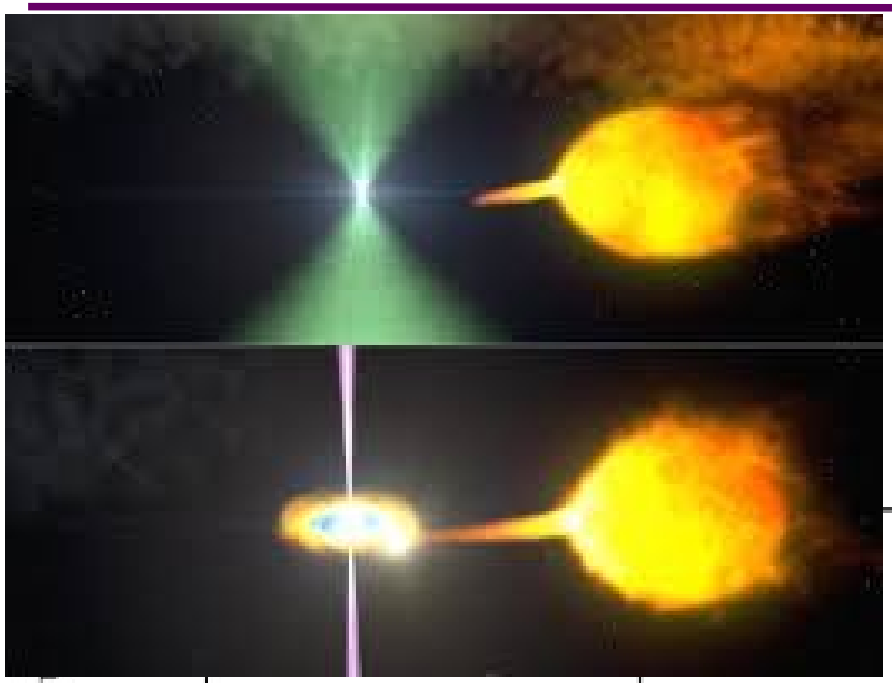


Radio

X-ray

(credit : J. Hessels)

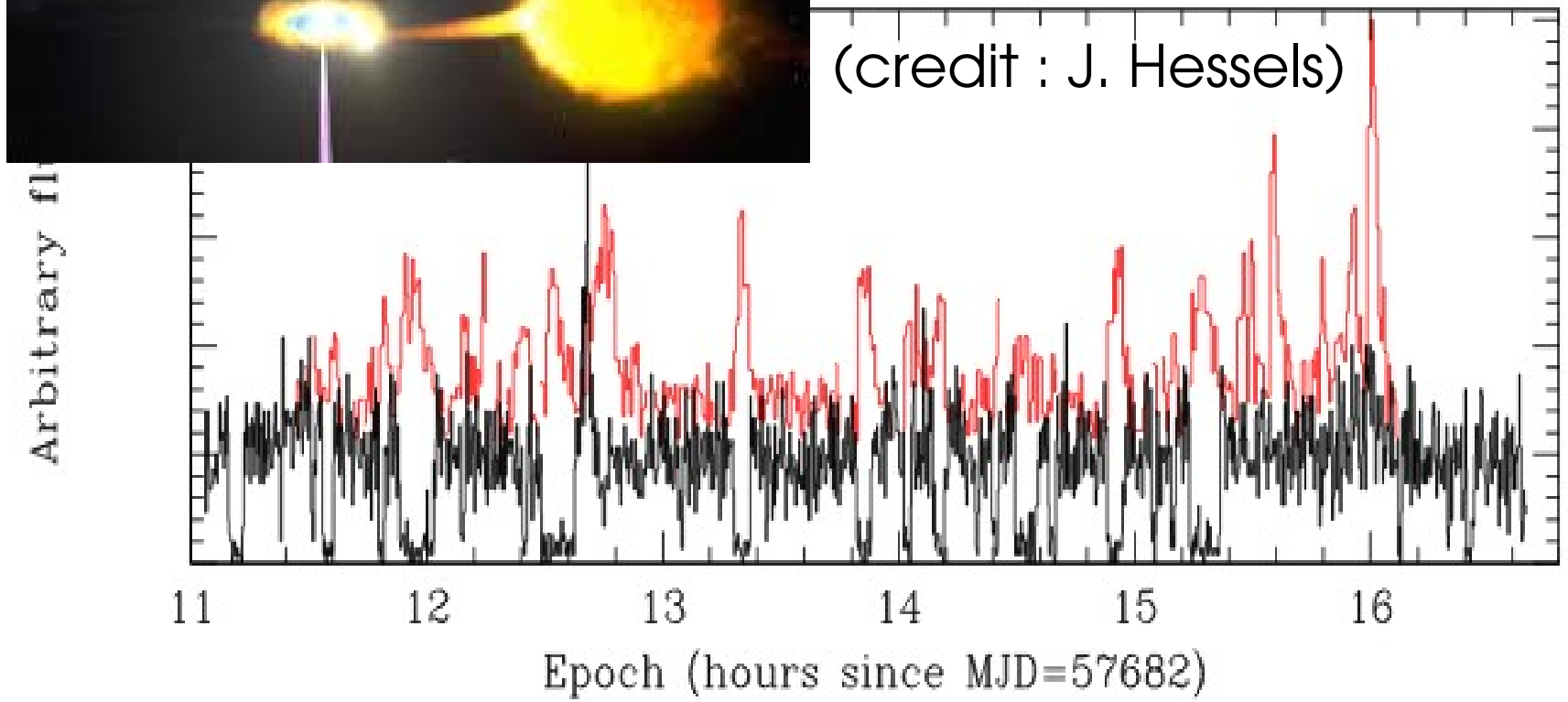
X-ray variability of accreting millisecond pulsars



Radio

X-ray

(credit : J. Hessels)



(Bogdanov et al 2018)

PSR J1023+0038

X-ray – black

Radio - red

Could pulsating ULXs show radio/γ-ray pulsations in the low X-ray state ?

Nançay Radio telescope (NRT) observations of two pulsating ULXs

NRT is worlds 5th largest radio telescope, but is a transit telescope

Typical pulsation detection limits with NRT are 54 μJy @1.4 GHz (1ks)
(with 512 MHz bandwidth using the NUPPI backend)

Observations should be made in X-ray low states

Difficult to anticipate radio fluxes expected
- can we extrapolate from the Crab ?

Radio observations of P13

P13 observed @1.4 GHz for 2.4 ks whilst in high state (4 April 2018)

Pulsar at 3.5 Mpc (Motch et al. 2014)

Blind search up to dispersion of 500 pc cm^{-3}, but no pulsations found

Radio observations of P13

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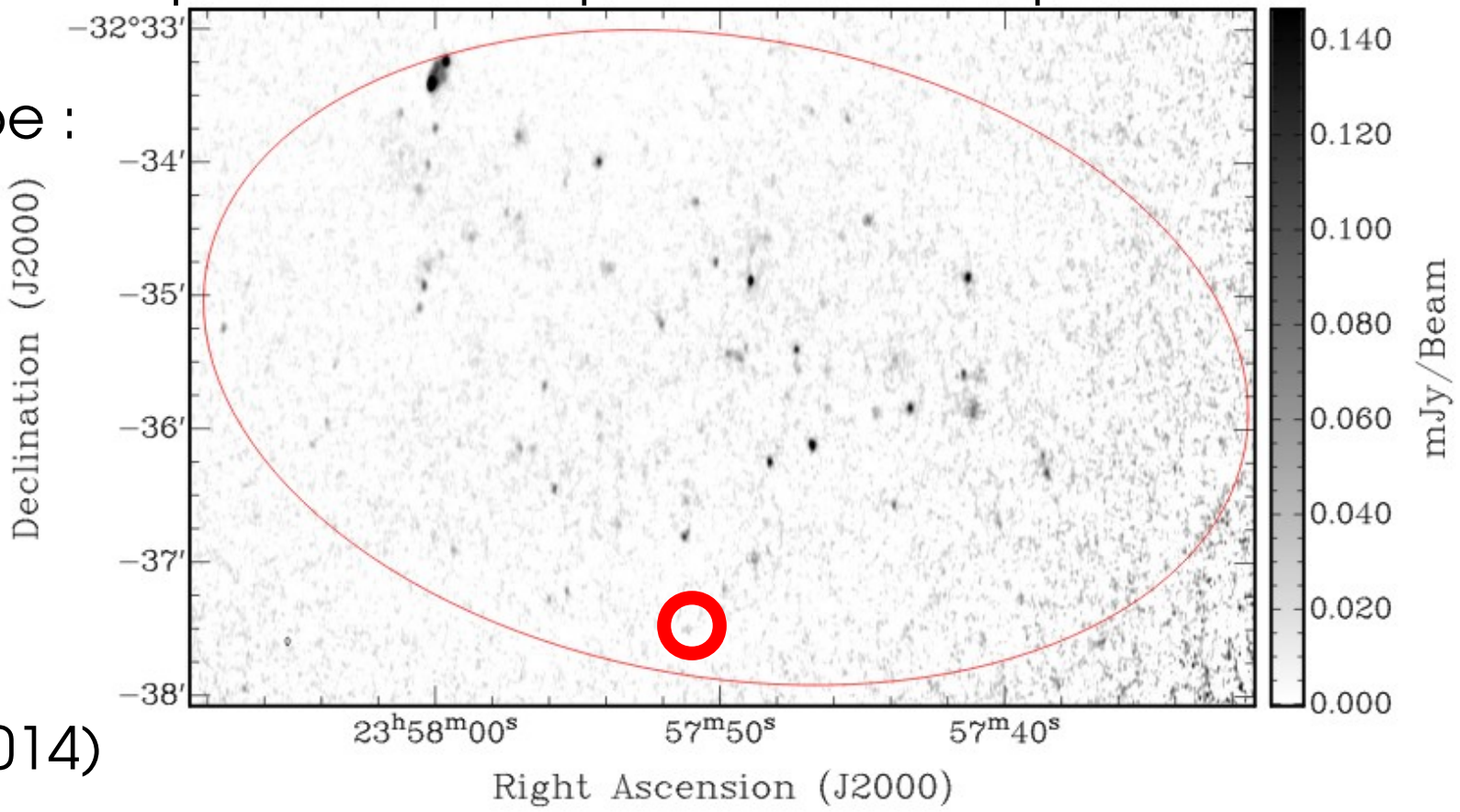
But there is hope :

ATCA, 5 GHz
(2009, 2010)

(Galvin et al. 2014)



Radio observations of NGC 5907 ULX1

NGC 5907 ULX1 observed @1.4 GHz for 4 ks whilst in an intermediate state (27 April 2018)

No pulsations found, but pulsar ~4x more distant than P 13 !

However, improved methods exist for searching for « slow » pulsars and these will be investigated

Fermi γ-ray observations of M 82 X-2

Fermi has detected >200 pulsars in γ-rays

Further, accreting MSPs show γ-ray emission when in the radio state

Using 7 years of Fermi data, a potential γ-ray counterpart to M 82 X-2 is detected (none for P 13 nor NGC 5907 ULX1)

The γ-ray counterpart may be due to star formation

Searching for a pulsation around the ephemeris revealed no significant pulsations

Future work

If radio/γ-ray pulsations can be found, the spin period will reveal if accretion has switched off, or just diminished

Detecting radio/γ-ray emission would help constrain the emission mechanisms

Future longer/ more sensitive observations in the low state may reveal pulsations in these objects

Detecting radio pulsations would be another way to search for new pulsating ULXs or pulsations in ULXs where no X-ray pulsations have been found!

The SKA, with a wide field of view (1-200 square degrees, 0.3-1 GHz), good sensitivity (0.4 mJy in 1 min) and excellent time resolution will be ideal to find new pulsating ULXs !