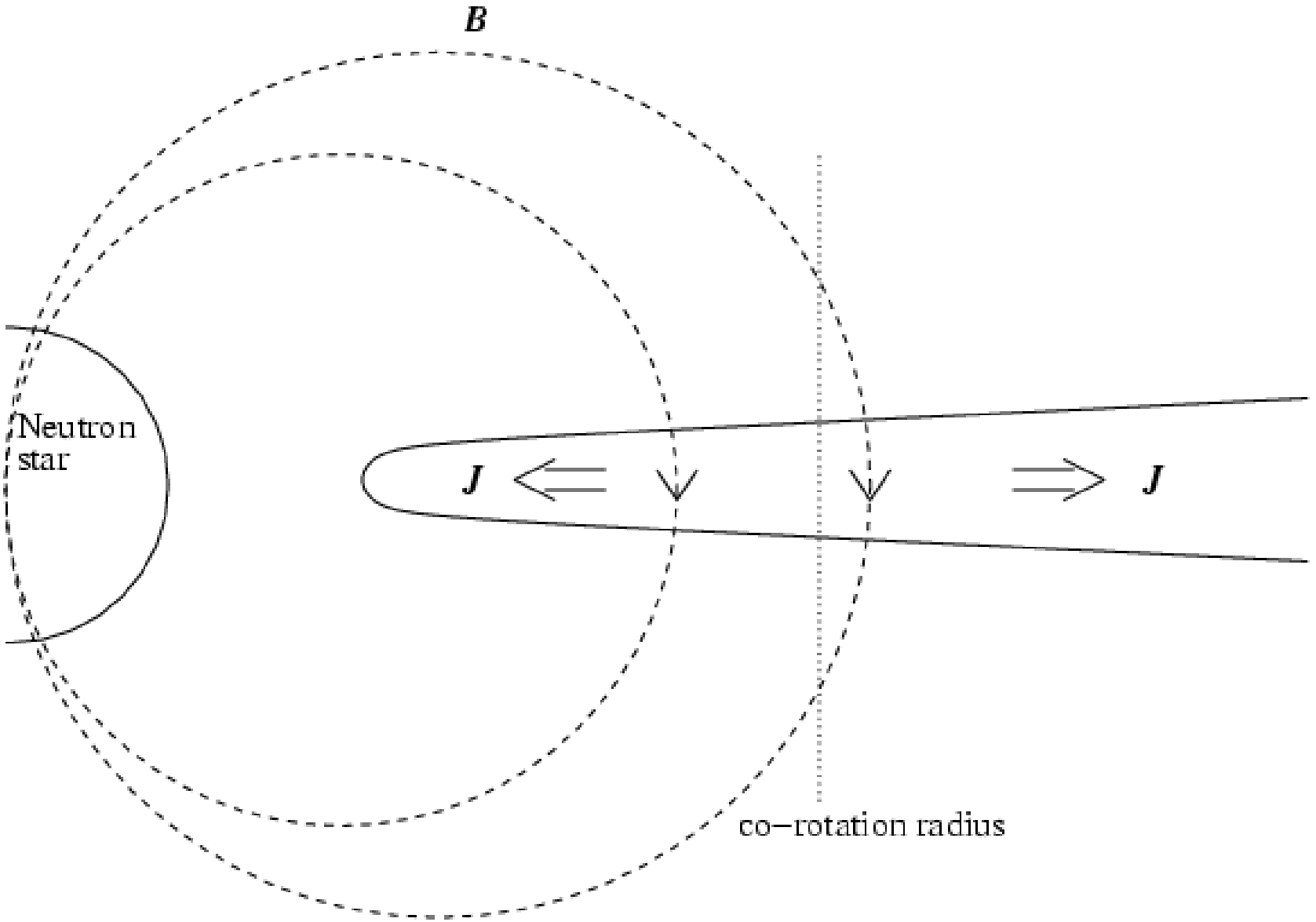
Accretion onto magnetised compact objects

Ulf Torkelsson
University of Gothenburg
Department of Physics

Outline

- Accretion discs around magnetised accretors
- Spin variations of X-ray pulsars
- The propeller regime and AE Aquarii

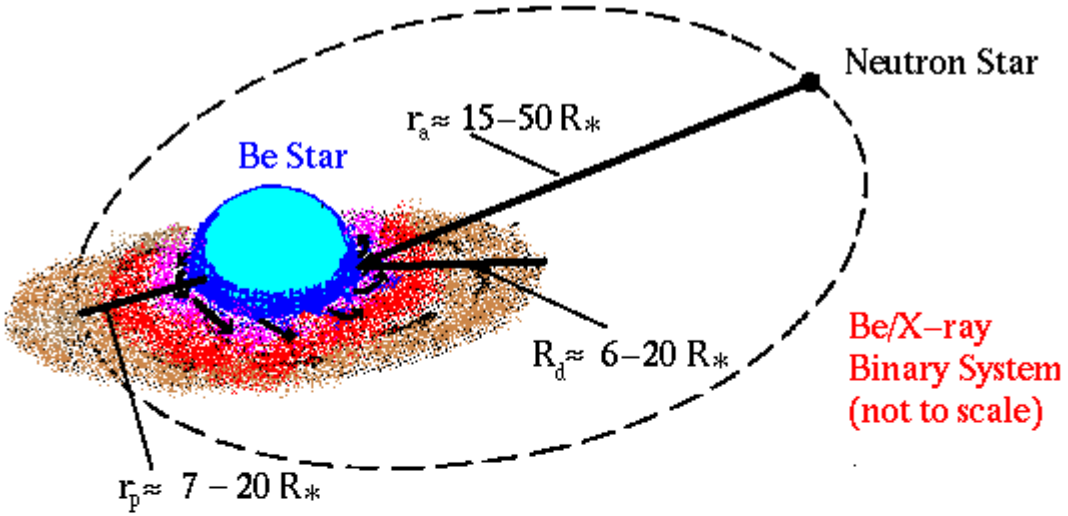
A disc around a magnetic accretor (Ghosh & Lamb 1979)

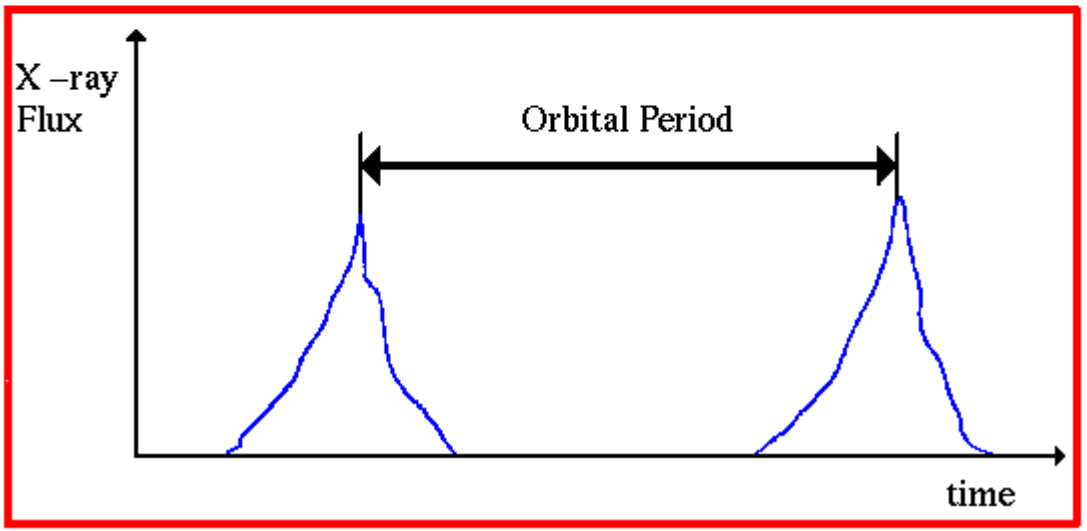


Spin evolution in the Ghosh & Lamb model

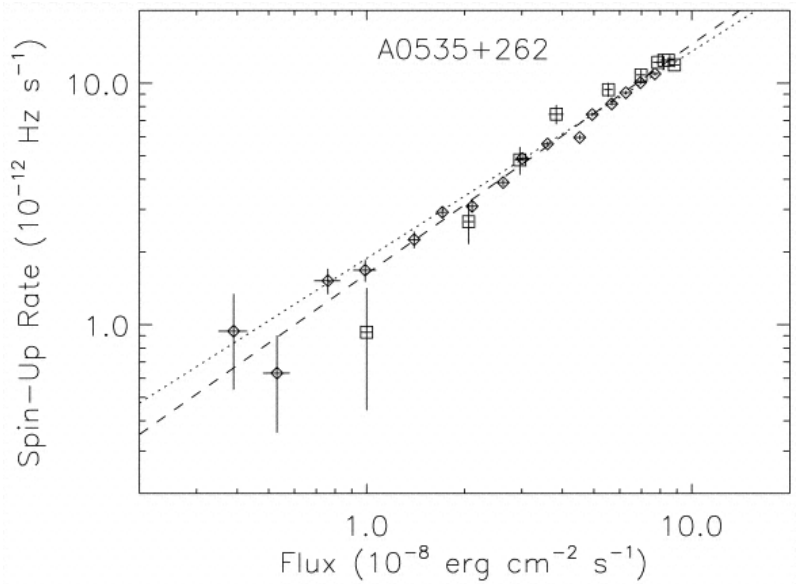
- As the accretion rate increases the inner radius of the disc shrinks
- This increases the spin up torque on the neutron star
- Prediction: A positive correlation between the accretion rate (X-ray flux) and the derivative of the spin period

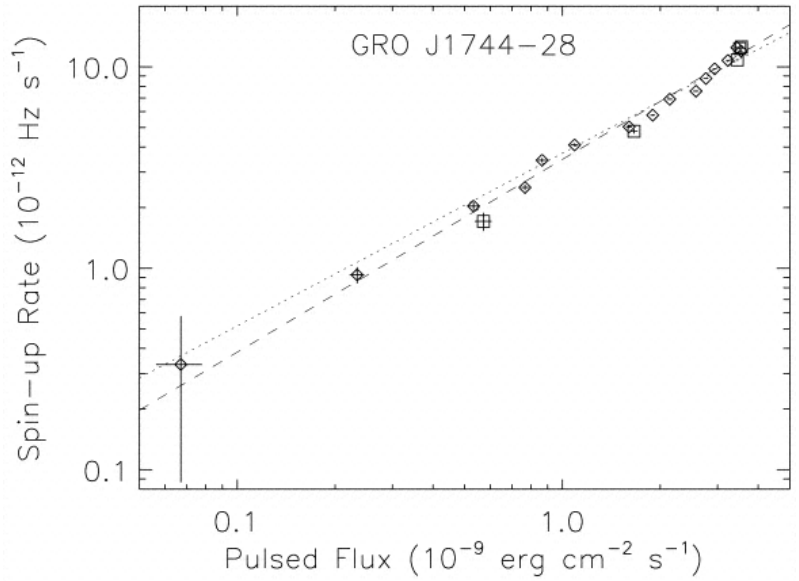
Be/X-ray transients (Negueruela 1996)





Two Be/X-ray transients (Bildsten et al. 1997)

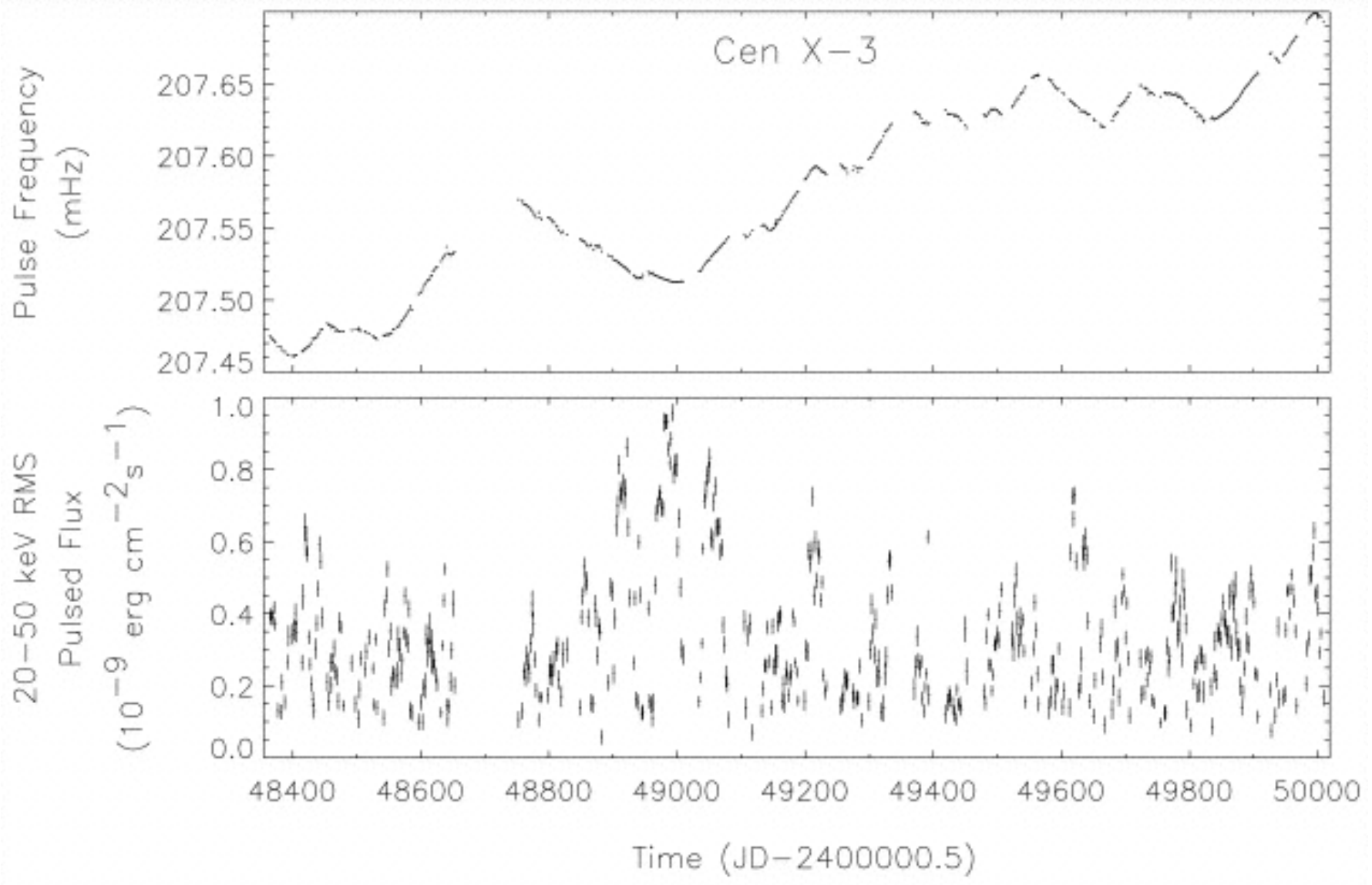




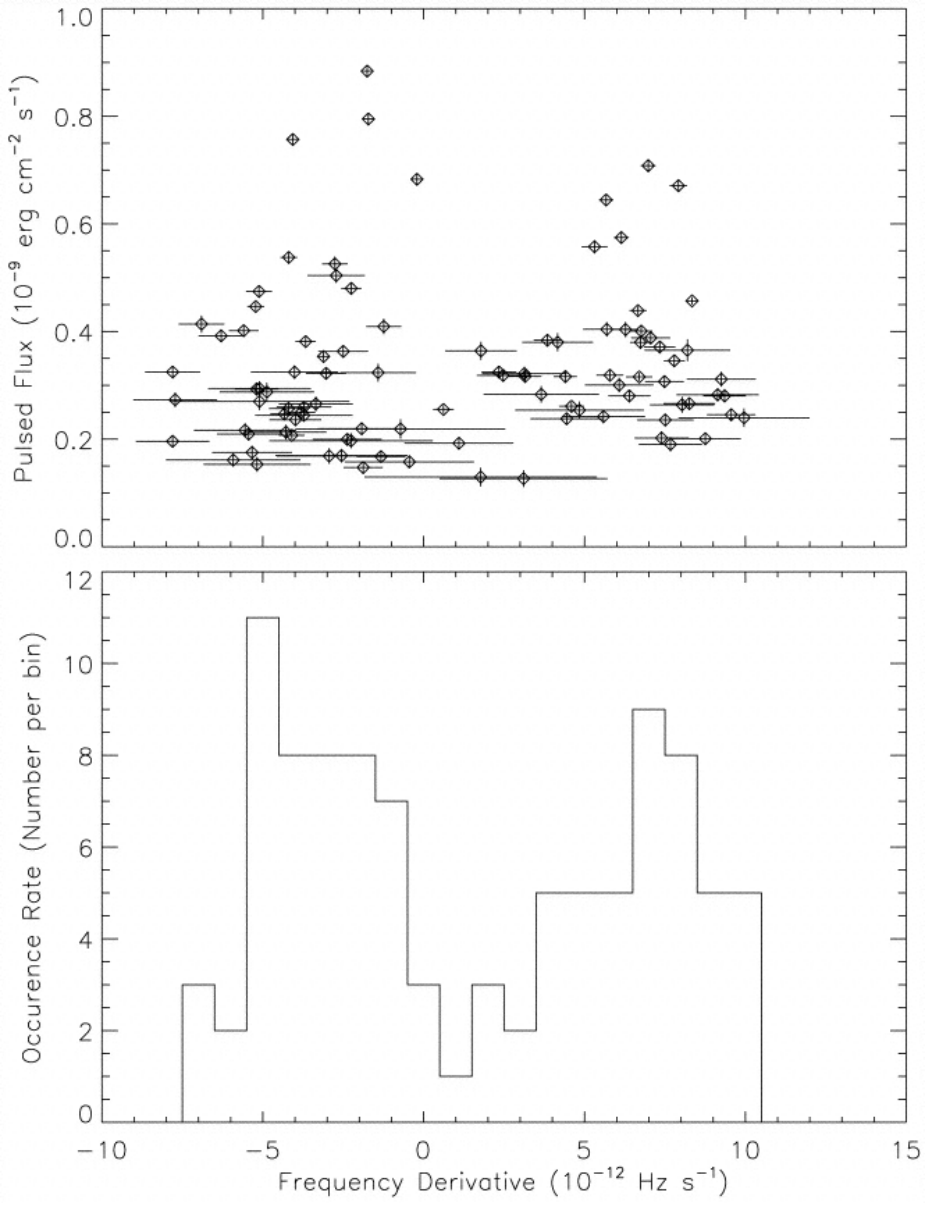
Bad news for LOFAR

- Be/X-ray transients are radio quiet
- Pestalozzi & Torkelsson are currently monitoring GX 301-2 and 4U 1145-619 using ATCA (November 2008 – February 2009)
- Observing strategy: We expect the radio emission to be delayed relative to X-ray outbursts with up to 0.4 orbital periods
- So far no detections at an rms of 0.1 mJy/beam

A steady X-ray pulsar with an accretion disc (Cen X-3, Bildsten et al. 1997)



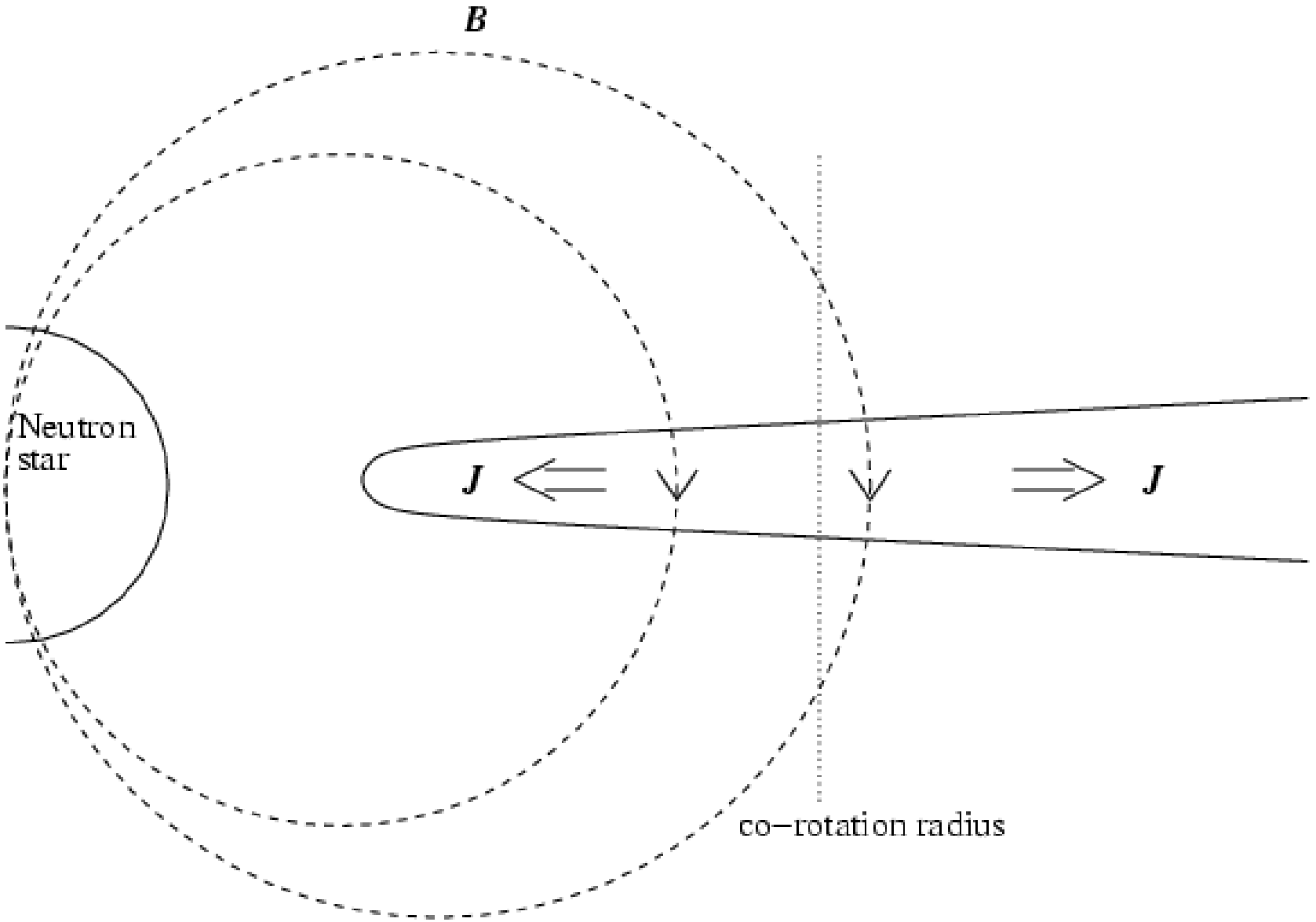
Torque on Cen X-3, (Bildsten et al. 1997)



Torque reversals in X-ray pulsars

- Formation of a counter-rotating accretion disc (Nelson et al. 1997)
- Warped accretion disc (van Kerkwijk et al. 1998)
- Non-Keplerian rotation in an ADAF (Yi, Wheeler & Vishniac 1997)
- An internal dynamo in the accretion disc (Torkelsson 1998, Belay & Torkelsson in preparation)

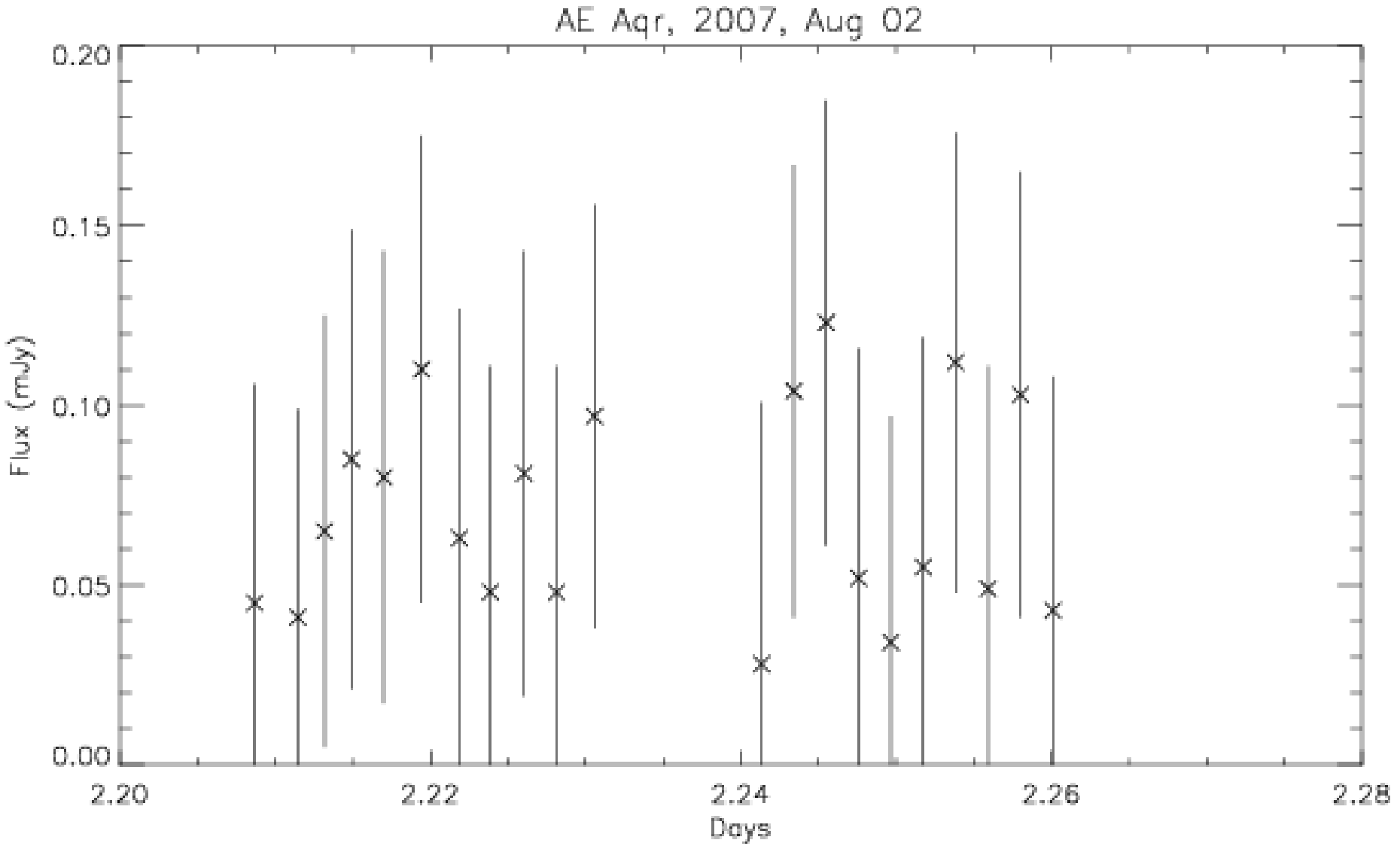
A disc around a magnetic accretor (Ghosh & Lamb 1979)



Propellers

- An accretion disc cannot form if the spin of the accretor is so large that the inner radius of the disc is located outside of the co-rotation radius.
- The inflowing material will then be ejected from the system
- The white dwarf in AE Aqr is in the propeller regime
- It is emitting over a wide range from radio to X-rays (gamma-rays).

Observations with Apex-LABOCA



Theoretical interpretation of the flares

- Wynn et al. (1997) have argued that the mass is transferred from the secondary in the form of blobs
- The blobs are shocked when they hit the white dwarf magnetosphere
- The shock heats the blobs and produce relativistic electrons (Venter & Meintjes 2006)
- The ejected blobs can thus produce both thermal and non-thermal flares

Relevance for LOFAR

- The radio emission from AE Aqr extends to much lower frequencies with a spectral index of 0.46
- The flares have been observed using the VLA at frequencies as low as 1.5 Ghz (Bastian et al. 1988)
- There is no evidence for periodic or quasi-periodic oscillations (Bastian et al. 1996)
- The flaring activity does not correlate with the orbital phase (Bastian et al. 1996)

Conclusions

- Be/X-ray transients are boring textbook examples of accretion onto magnetized stars
- However there are other systems that show that there is still more to learn about the interaction between an accretion flow and a magnetosphere
- Some of these systems can be explored using LOFAR