Missing the other pole

We now discuss an issue arising in the precessional interpretation of B1828-11 and other pulsars which demonstrate a double-peaked spin-down rate. The precessional interpretation asserts that the two harmonics naturally arise in pulsars for which $\chi \approx \pi/2$. In such circumstances the precessional wobble causes the magnetic dipole to wander of the rotation equator. This is a maximum in the torque and as such coincides with a minimum of the spin-down rate.

If such an interpretation is to be believed, then we should expect to see an inter pulse corresponding to the other pole. To illustrate this consider an observer in the northern hemisphere of a pulsar undergoing free precession. We denote the fixed angular momentum vector of the star by $\boldsymbol{J}$ and set the spin-vector to be at a small angle θ to $\boldsymbol{J}$. The motion of the EM dipole can be understood as tracing a cone about $\boldsymbol{J}$ of half-angle Θ at the fast rotation frequency; precession then causes a slow modulation of the dipoles polar angle Θ by an amount $\Delta\Theta$. Since the observer will only observe a pulse when the dipole cuts the plane containing the observer and $\boldsymbol{J}$, we can illustrate the picture using the diagram in Fig. 0.0.1. On the long precession time scale, the observer sees $\hat{\boldsymbol{m}}$ oscillate in the range $\Delta\Theta$ depicted in the figure.

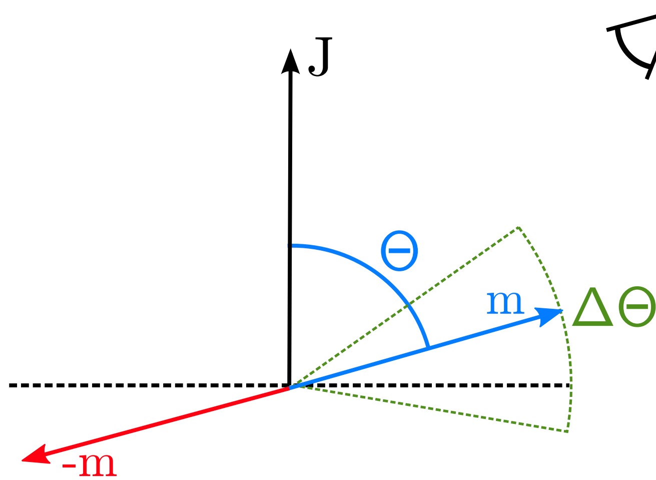

Figure 0.0.1: Illustration of the observer, the angular momentum vector $\boldsymbol{J}$ and the two sides of the magnetic dipole $\hat{\boldsymbol{m}}$ as it cuts the plane containing the observer and angular momentum vector.

In this image we have presented a rather special case, let us first review the more general case:

- With $\Theta < \pi/2$, then the angular distance between the blue pole of the beam and the observer is always larger than that between the red pole and the observer (at π out of phase from this picture when the red pole is on the observer side of $\boldsymbol{J}$ and hence beaming towards the observer). In such a case the observer, if they see any pulses at all, will always see the blue pole as the most intense beam. If the beam is sufficiently strong and or $\Theta \approx \pi/2$ (but still smaller), then the observer may also observe the red pole as an inter-pulse π out of phase from the blue pole.

- If Θ ranges over $\pi/2$ as shown in Fig. 0.0.1 then the blue pole is not always the closest angular distance to the observer: during the period for which $\Theta > \pi/2$, the red pole will have a closer angular separation to the observer when beaming towards the observer. Now, provided the intensity of both beams are approximately equivalent, the observer must see the 'inter-pulse' stronger than the main beam.

For B1828-11 several publications have estimated best-fit parameters which would cause the beam to wander of the rotational equator, yet no inter-pulse or any evidence of a second beam is observed. One possible explanation is that the red-pole is misaligned in a polar-sense from the blue-pole. In figure 0.0.2 we illustrate such a case labelling the angle of misalignment by λ. Pulsars are observed with this geometry [need to fill in typical ranges].

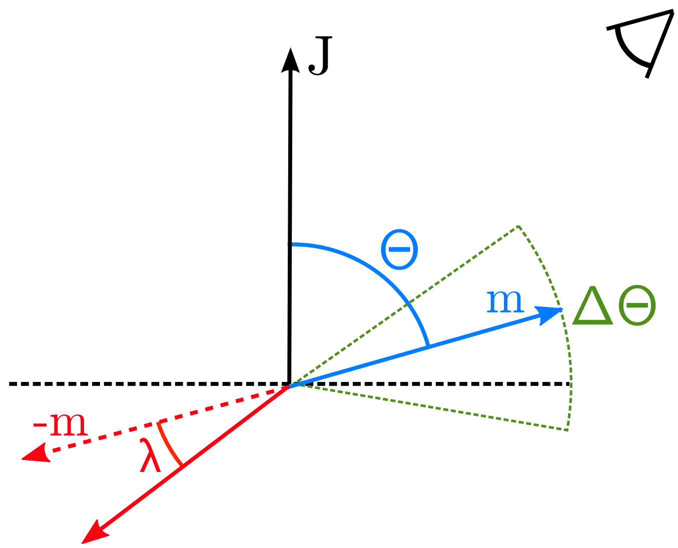

Figure 0.0.2: Repeat of Fig. 0.0.2 with the addition of a misaligned red pole.

The absence of any observed inter-pulse in B1828-11 can then be explained if

$$\lambda > \langle\Theta\rangle + \Theta/2 \tag{0.0.1}$$

which would prevent the red pole from rising into the northern hemisphere and becoming as bright as the observed pulse. Of course, we could also postulate that the red pole is a weaker beam..