Gamma-Ray Pulsars; Geminga and PSR B0656+14

Bradley E. Schaefer, Zachary I. Edwards, Zhichao Xue
Department of Physics & Astronomy, Louisiana State University
(schaefer@lsu.edu)

Geoff Burbidge famously said "You can divide astronomy into two parts: the astronomy of the Crab Nebula and the astronomy of everything else." While clearly an exaggeration, this expresses the importance of the Crab for many fields in astronomy. The Crab pulsar, at V=16 and on the ecliptic, would be a great target for the K2 mission (with it having large Gamma-Ray flares, glitches, and giant pulses), but the Crab slips between Fields 0 and 4. There are only three other Crab-like Gamma-Ray pulsars (Geminga, PSR B0656+14, and the Vela pulsar), with two of them fitting inside Field 0. So we are proposing to use this unique opportunity for Kepler to observe the two Gamma-Ray pulsars, Geminga and PSR B0656+14, both with 30-minute cadence.

A substantial problem is that both pulsars are near 25th magnitude, so they will only be detectable if they flare brighter than 21st mag or so. Shibanov et al. (2006) give the R magnitudes to be 25.5 and 24.6, with middling colors. The DSS shows there to be no stars to 21st mag within 20 arc-seconds. Deep Subaru images (Shibanov et al. 2006) show that both pulsars have no brighter stars within 9", and those are only ~23rd mag stars only in one direction from each pulsar, so the flux from tail of the PSF of the nearby stars will be fainter than 23rd mag. Given the various backgrounds and the readout noise per pixel (see http://keplerscience.arc.nasa.gov/CalibrationSN.shtml), the SNR will be roughly 10 (i.e., with a confident detection of a flare) when the pulsar gets to 21st mag, for a single 30-minute integration. With longer intervals of binned data, we might be able to detect 22nd mag flares, and these would be with the pulsar brightening only by around a factor of ten.

There are reasonable grounds for expecting that the two pulsars will flare bright enough to be detected. One possibility is that the pulsar will glitch (i.e., have some crustal movement event that causes a jump in the neutron star rotation period), for which a sudden release of so much energy could well produce a lot of optical light. Both of our targets are known to have glitches (Espinoza et al. 2010), with energies of $\sim 10^{46}$ ergs. If just 10^{-11} of the glitch energy comes out in the optical band over a few hours, then Kepler can detect the flare. Another possibility comes from the recent discovery that the Crab undergoes very powerful gamma-ray flares with energies $\sim 10^{41}$ erg, durations of ~5 days, and coming several times a year on average, so any associated optical component or tail would produce a large optical brightening. If just 10^{-4} of the flare energy comes out in the optical over a few days in our targets, then Kepler should detect the flare. So while it is speculative that the two pulsars will suffer large amplitude flares, there do exist plausible physical mechanisms. Kepler now offers the ability to monitor Crab-like pulsars in the optical for a substantial length of time. This is will be the first time such a study has been done for any pulsar, therefore we are not sure what to expect.

Espinoza, C. M. et al. 2011, MNRAS, 414, 1679.
Shibanov, Y. A. et al. 2006, A&A, 448, 313.