Notes on reduction of Crab observations

(on timing of polarized images in optics)

by Alexander Panferov

Detection of periodical phase variation of the pulse:

Period 101 min, maximum $\dot{P}/P \approx 2 \cdot 10^{-8}\,\mathrm{s}^{-1}$, —

that means several Earth mass component if it is. However, 1) data were not designed for the precise timing and have some serious drawbacks (e.g. absence of GPS reference), and 2) the found periodicity is not observed in radio.

Observations: 6-m telescope (Russia), MANIA+PSD (on the basis of multichannel plates, with nowadays parameters *q.e.* $> 10\%$, inch x inch, resolutions of $50\,\mu$m and $1\,\mu$sec), observers G. Beskin, V. Plohotnichenko, ..., 01/09/2000, duration 22:30 – 02:30 (including short gaps between exposures), i.e. 4 hrs. In total, 12 exposures of 20 min every, except in B where it was for 10 min, in polarized light in BVR bands and for two polarization angles. This polarization mode of observations (polarization was the target of the observations) severely complicates data reduction. Also there was not control of device clock relatively absolute time standard (GPS).

Precision of timing is $\approx 1\,\mu$s — one of the best achieved for Crab optical imaging. Nobody observations of such type have continuously spanned even for one detected 101 min period.

A radio band is different in a nature of the radiation mechanism and a way of handling with data. Usually the time of arrival (TOA) of photons of the Crab pulsar has scatter (noise) of $\approx 30 \div 100\,\mu$s relatively ephemerids — therefore one could miss the revealed upper periodicity, which has an amplitude of $\approx 30\,\mu$s. For an example, the most precise observations in radio with VLA by Moffet & Hankins (1996, ApJ **468**, 779), with TOA rms of $4\,\mu$s per 30 min session of observations, revealed much worse rms for the day set and a scatter of $50 - 100\,\mu$s from session to session. Crab pulsar differs from others in big random walk, has strong dependence of the pulse phase curve on radiation frequency. There is possibility of what has relation to the detected periodicity, being generated in optics, on spatial scale of $\sim 10^6$ cm, that is dispersed and swallowed as long as being transferred to radio-zone, on bigger scale of $\sim 10^8$ cm.

Reduction of the data were carried out with specially designed program (CRAB), of type of TEMPO but designed for images. The program allows to manipulate (X,Y,T) data of individual photons. It has functions usual for imaging and specific those for deconvolution of image, and phase folding of image.

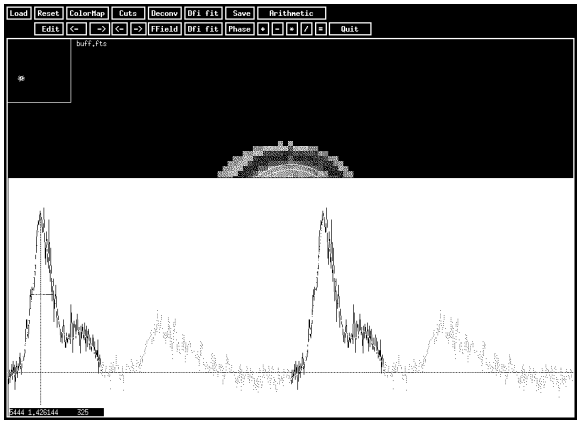

Figure 1: Appearance of the CRAB window in iterative process of the timing of optical image of Crab pulsar.

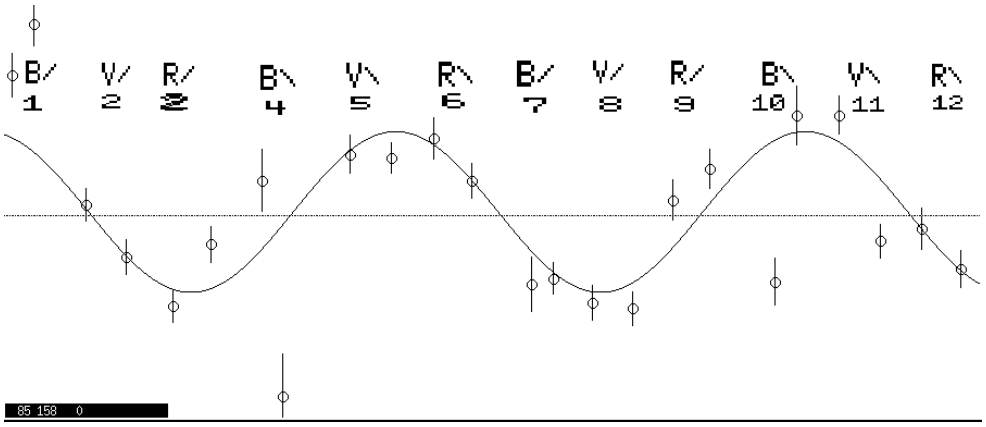

Figure 2: Change of TOA relatively the spin-down model for Crab pulsar in optics for the main pulse. X axis — time of observations. Data for only one polarization are shown. There are marked optical bands and sense of angle of polarization analyzer.

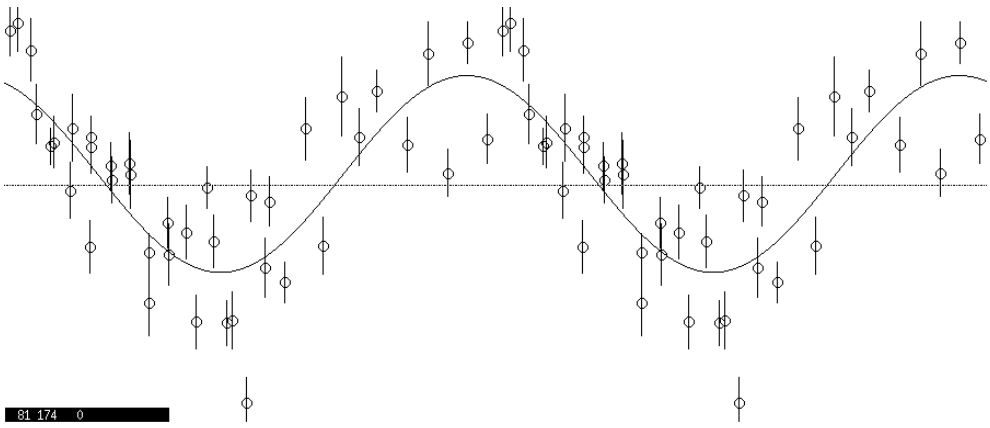

Figure 3: Residuals between TOA and spin-down model folded with a period of 101 min for the main pulse and only for V and R data in one polarization. X axis — two 101 min phases.