Group Delay in a Microwave Millisecond Oscileating Event

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An event demonstrating periodic narrowband millisecond pulsations of radio emission both in intensity and polarization degree is analyzed. Data are obtained with the 2.60-3.80 GHz spectrometer/polarimeter of the Beijing Astronomical Observatory having high frequency (10 MHz) and temporal (8 ms) resolution (Fu et al, 1995). The delays between L- and R-polarization components are found (Figure 1).

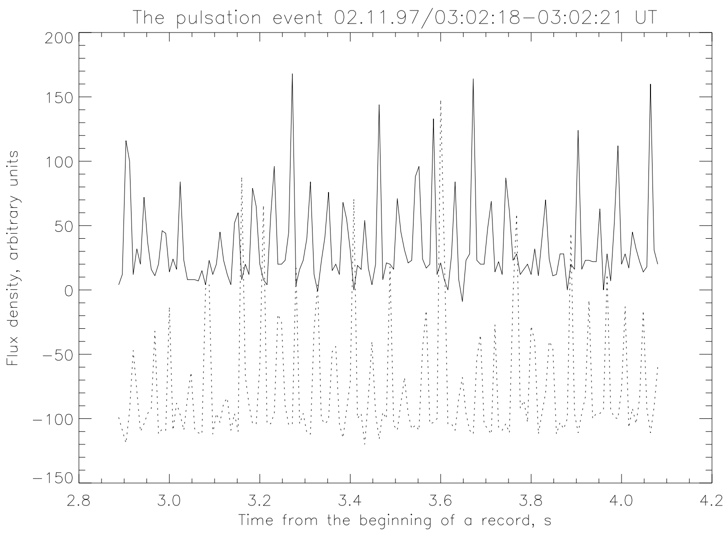

Fig.1.Time profile of pulsations at f = 2.85 GHz for R (solid line) and L (dots) components.

The Fourier analysis of the pulsations reveals quite strong frequency dependence of the delays (Figure 2). The dependence is a power-law with the spectral index varying in the limits of 2.5 ± 0.8 (depending on a time segment of the pulsation event).

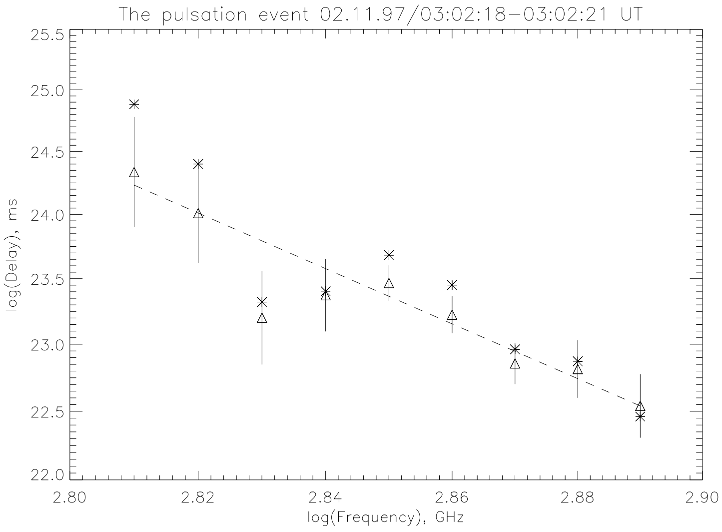

Fig.2.Delay-frequency dependence for pulsations. The delays are taken at the frequencies of FFT maxima for R (asterisk) and L (triangle) components. $R = 0.93$, $y = a + b * x$, $b = -2.58 \pm 0.15$.

It is shown that the radio emission is generated by plasma mechanism at the second harmonics of the upper-hybrid frequency. Oscillations of the radiation polarization degree arise due to group delay between extraordinary and ordinary modes along the line of sight. Physical parameters of the emission source and "delay site" are determined within the proposed model based on current theory of nonlinear plasma mechanism of radio emission (Fleishman et al., 1994, Fleishman and Korsakov, 1999):

- Background plasma density	$n \approx 1.5 \times 10^{10} cm^{-3}$
- Kinetic electron temperature	$T \geq 10^7\ K$
- Number density of fast electrons	$n_b \sim 3 \times 10^4\ cm^{-3}$
- Plasma wave growth rate	$\gamma_{max} \sim 200\ s^{-1}$
- Spectral bandwidth of generated plasma waves	$\Delta\omega/\omega \approx 1.8\%$
- The range of wave vectors of generated plasma waves	$c\Delta k/\omega_{pe} \approx 3$ or $\Delta k d_e \approx 0.1$
- The direction of maximal amplification of plasma waves	$\theta \approx 80^o$
- Angular bandwidth of generated plasma waves	$\Delta\theta \approx 20^o$
- The level of plasma turbulence	$w = W/nT \approx 10^{-6}$
- Brightness temperature	$T_b \approx 10^{14}\ K$
- Linear scale of the source	$L \approx 100\ km$

and for delay site

- Delay parameter	$BH \approx 0.9 \times 10^{12}$ Gcm or $B \approx 500$ G for $H \approx 2 \times 10^{9}$ cm
- Predicted variation of the group delay from lowest to highest frequency	$\delta t_g \sim 1$ ms

Therefore, we conclude that carefull interpretation of radio data with hight temporal and spectral resolution provides very detailed diagnostics of the plasma both inside the emission source and along the line of sight.

References

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