

# Radio and Hard X-ray Quasi-Periodic Pulsations during the 2004 July 13 Flare

K.Hori(1), S.Pohjolainen(2), T. Sakurai(1)

(1) National Astronomical Observatory of Japan, (2) Univ. of Turku/Tuorla Observatory

Quasi-periodic pulsations (QPPs) in radio and hard X-ray emissions have been observed in association with solar flares. Typical pulsation periods of QPPs range from a few seconds to several minutes. Possible causes of the intensity variations in radio emission are (i) fluctuation in the number of particles created by the acceleration process, (ii) modulation in the whole structure in which the radiation takes place (MHD oscillations), and (iii) modulation in spatial and energy distributions of the radiating particles (Trottet et al. 1979). Among them, the fast sausage-mode MHD oscillation has been preferably interpreted as a cause of QPPs, which is manifested in coronal loops by symmetric cross-sectional variations and plasma compression. This compressive mode is nearly transversal and the perturbations of plasma velocity in the radial direction are stronger than those along the field (Nakariakov and Verwichte 2006).

Recently, Asai et al. (2001) detected spatially resolved microwave QPPs for the first time with the Nobeyama Radioheliograph (NoRH). NoRH can provide microwave images with a time resolution up to 0.1 sec and thus suitable for the study of spatially resolved QPPs. Asai et al. (2001) investigated the oscillation with a periodicity of 6.6s in the context of the fast kink-mode, rather than the fast sausage-mode. In their interpretation, the QPPs can be due to the modulation of the electron acceleration by a global kink oscillation of the flaring loop, or by an interaction of the flaring loops with another loop which performs kink oscillations (Nakariakov and Verwichte 2006). However, the spatial resolution of the radio (and HXR) data is not sufficient to observe the loop oscillations. The interpretation in terms of the sausage-mode is still possible (Aschwanden et al. 2004).

We introduce the QPPs in radio (9.4–35 GHz; NoRH) and HXR (25-100 keV; RHESSI) emissions, which were well correlated for 200 sec with a period of about 20 sec. The event occurred at AR10646 (N14W45) on 2004 July 13 during an M6.7 flare that produced an EIT wave, metric type-II bursts, and a partial halo CME. The HXR images show an asymmetric double source with a separation of about 20", which presumably corresponds to conjugate footpoints of a flaring magnetic loop. TRACE EUV images show a dark filament lying above the double source. The filament began to erupt after the start of the QPPs. NoRH 17 GHz images show a single source centered between the HXR double source. SOHO/MDI magnetograms suggest that this flare was triggered by a magnetic flux that emerged around the HXR sources.

Time profiles of the HXR and microwave emissions suggest a magnetic trapping of nonthermal electrons in the flare loop. We concluded that our QPPs were caused by modulation in the emitting region, rather than fluctuation in the acceleration process. We therefore argue that the sausage-mode is a better candidate. A causal relationship between the QPPs (confined in the loop) and the associated outward propagating ejecta and shock waves will be addressed.

#### References

Asai, A. et al. ApJ 562L, 103, 2001 Aschwanden, M. J. in Proceedings of the SOHO 15 Workshop, pp97-107, 2004

Nakariakov, V.M. and Verwichte,E. "Coronal Waves and Oscillations", 2006

Trottet, G., Pick, M., & Heyvaerts, J. A&A 79, 164, 1979