Radio and Hard X-Ray Quasi-Periodic Pulsations in Association with Flare Ejecta and Propagating Shock Waves

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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).

In the previous meeting in Kyoto (2005 Sep 29), we introduced 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, 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 argued that the sausage-mode is a better candidate for our event.

In this meeting, we further investigate the QPP event in order to address a causal relationship between the QPPs (confined in the loop) and the associated outward propagating ejecta and shock waves. By comparing radio data set from Nobeyama radio polarimeter (1-35 GHz) and NiCT HiRAS dynamic spectra (25-2500 MHz), we found a possible driver of the metric type II burst.

References

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Aschwanden, M. J. in Proceedings of the SOHO 15 Workshop, pp97-107, 2004
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