Observation of fine structures in solar radio burst spectra in the UHF band

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It is well known that solar radio bursts in the UHF band accompany some spectral fine structures such as metric spikes related to type III bursts, and zebra patterns and fiber bursts observed in type IV bursts. These fine structures are characterized by their narrowband and short-lived signatures in dynamical radio spectra. Especially, the metric spikes have short duration time of few 10 msec and narrow bandwidth of a few MHz. Despite extensive studies over a half of century, the generation mechanisms of the fine structured radio bursts have not been identified yet. One of the reasons is the limited resolutions of the previous spectral observations compared to the scales of the fine structures in both time and frequency. In order to clarify the detailed spectral features of the fine structures of solar radio bursts, in the present study first we developed a new instrumentation having high resolutions enough to identify the fine structures.

The new instrumentation developed at Zao observatory of Planetary Plasma and Atmospheric Research Center, Tohoku University, is designed to identify the spectral structures in the frequency coverege of 316 - 334MHz. The original system at Zao observatory is an array antenna system for the observation of Jovian synchrotron radiation. We rearranged the system in order to observe with one antenna and record the radio spectral data through high speed transmission. Moreover, a new control system was installed to the radio telescope for tracking the sun and monitoring the system remotely. These improvements enable us to observe the sun steadily.

After the set up of the observation system, we evaluated the characteristics of the devices and clarified that the system has sufficient performance for the observation and the values are enough to observe the radio bursts.

While the observation has been operated since the middle of June in 2008, two solar radio burst events are detected on July 19 and during a period from November 2 to 3, 2008. In the event of July 19 (07:36:10-07:36:25 UT), a group of type III bursts is observed with the drift rate of 160 - 260 MHz/sec. The start frequency of these type III bursts are defined at around 350 MHz with the spectral data obtained by HiRAS. Subsequently, during 07:36:18 - 07:36:18.6 UT, drifting spectral fine structures is identified in a type III burst with drift rates of -39.7 - -66.7MHz/sec, which are one order smaller than the drift rate of the parental type III burst. This is the first report of the spectral structures with the smaller drift rate superimposed to the main component of type III bursts. Assuming that the spectral structures are characterized by electron beams, we consider additional electron beams having velocities smaller than the beams responsible for the generation of the ordinary type III bursts. We propose two possible explanations of the formation process of additional electron beams responsible for the small frequency drifting bursts, but it is difficult to clarify which is plausible because the limitation of the frequency coverage of the observation system prevents us to identify the start frequency of the type III bursts.

Type IV bursts are observed during the observation pediods of 21:27 - 22:30 UT and 23:02 - 23:14 UT on November 2, 2008 and 02:02 - 02:06 UT, 03:11 - 03:15 UT, 05:15 - 05:20 UT on November 3, 2008. It is confirmed that every group of type IV bursts involve spectral fine structures, such as fiber bursts and zebra patterns. The statistical analysis of the drift rate of the stripes reveals that a part of fine structures which is consistent with the previous studies, but we also detect a number of fine structures having drift rates very faster than the typical values. The distribution of the drift rate of every burst group has a peak value around 50 - 75 ¥mathrm{MHz/sec, while the previous studies suggested 9.14 MHz/sec for the typical drift rate of stripes.