Type II and Type V Solar Radio Observed in Alaska

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Soon after the start of the UTC day on 15 July 2023, the Sun produced Type V and Type II radio bursts that were received at the HAARP Radio Observatory near Gakona (figure 1) and also at the Cohoe Radio Observatory, both in Alaska. The Type V consists of Type III fast sweep radio bursts followed by an interval of continuum emission. Type III radio bursts frequently precede Type II slow sweep radio bursts and did so here. In turn, Type II bursts may also involve Type IV emissions but, in this case, the Type IV did not exist or was too weak to be seen in the recorded spectra.

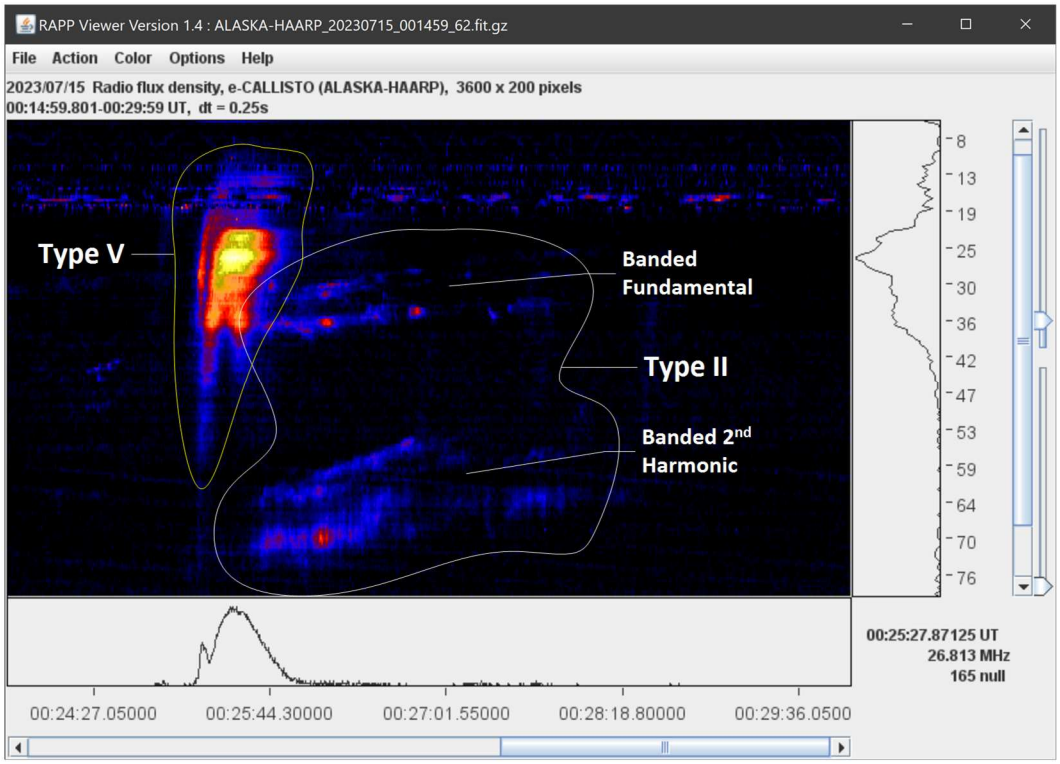

Figure 1 ~ Annotated spectrogram showing overlapping Type V (yellow line) and Type II (white line). The Type II has a fundamental and 2nd harmonic, both with a split-bands. The horizontal scale shows time in UTC and the vertical scale shows frequency in MHz. The cursor position (not visible) is at the center of the Type V with corresponding relative intensity traces below and to the right.

These radio phenomena are associated with solar flares, which are explosive events in the Sun's chromosphere. Flares most often are related to instabilities in the solar magnetic fields near or part of a sunspot. The frequencies of solar radio emissions produced by flares depend on the electron density (and associated plasma frequency) and magnetic field intensity where the emissions are produced; for emissions in the HF and VHF bands, such as those discussed here, the locations usually are above a sunspot in the Sun's corona. The emissions are mostly unpolarized.

The Type III bursts are thought to be produced by relativistic (near light-speed) electrons accelerated by flare energy release. These electrons tightly spiral around strong solar magnetic field lines and their accelerations produce a beam of electromagnetic emissions. As the disturbance moves outward through the corona, the frequency drifts from high to low in correspondence with the progressively lower coronal electron density. Sometimes a bulb or blob of continuum radiation is observed in the spectra with Type III bursts. The combination of the Type III with the continuum is called a Type V. The Type V follows in time the Type III bursts

and may be a trace of the Type III's passage through the corona, or it may be a group of slower electrons that follows a different magnetic field configuration and emits a different spectral signature.

The Type II bursts are produced by the ejection of a huge amount of plasma (billions of tons of charged particles) that forms a magnetohydrodynamic (MHD) supersonic shockwave moving through the Sun's corona at velocities up to a few thousand kilometers per second. The cloud of particles is called a *coronal mass ejection* (CME). Type II bursts can include a 2nd harmonic. The harmonic ratio usually is around 10% less than 2. Band-splitting is often associated with Type II bursts in which the fundamental and 2nd harmonic seen in the dynamic spectra are each split into two distinct spectral regions. These split-bands are thought to be produced upstream and downstream of the MHD shock front. The Type II drifts from high to low frequency but at a much lower rate than the Type III owing to the former's lower velocity.

Instrumentation:

- HAARP Radio Observatory, Gakona, Alaska: 62° 23' 20.93"N, 145° 8' 15.51" W, 562 m AMSL
  - LWA Antenna (figure 2) connected through an LWA Power Coupler with quadrature coupler and RF power splitters
  - Dual up-converter, 5 – 85 MHz RF input, 205 – 285 MHz IF output
  - Two Callisto spectrometers, 205 – 285 MHz RF input, RHCP and LHCP, Callisto software with FITS file output
  - RAPPViewer software to produce the spectrogram from a Callisto FITS file

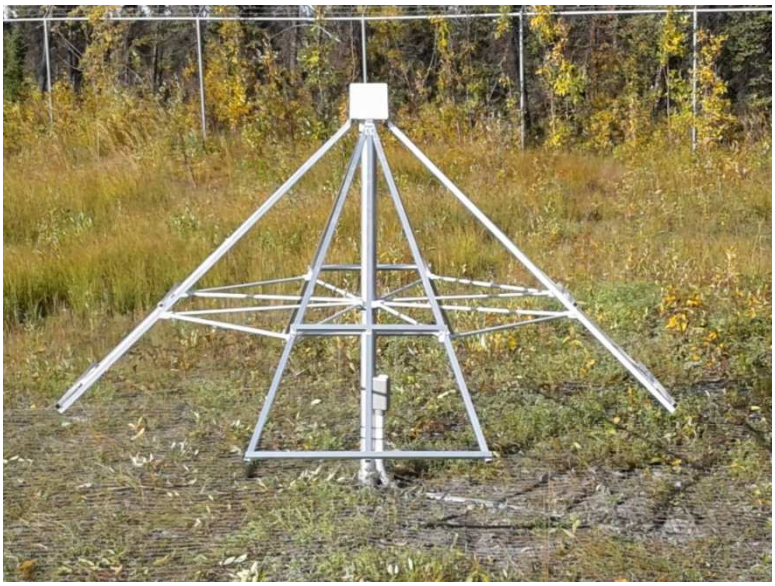

Figure 2 ~ LWA Antenna at HAARP Radio Observatory soon after installation in September 2021. The antenna is an active, tied-fork, crossed-dipole, 1.5 m high with the Front End Electronics (FEE) in the square hub enclosure at the top. The antenna and associated spectrometers are collocated on the science pad with the Modular UHF Incoherent Radar (MUIR) at the HAARP facility. The chain-link fence that surrounds the science pad can be seen in the background about 25 m away. Image © 2021 W. Reeve.

Resources:

- Solar radio burst types: https://reeve.com/Solar/Solar.htm
- Type II Slow Sweep Radio Bursts: https://www.reeve.com/Documents/CALLISTO/Reeve_TypeII-Burst.pdf

Acknowledgements:
Callisto FITS files, credit: FHNW Brugg/Windisch and IRSOL Locarno, Switzerland, {Callisto}