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LOFAR observations of neutron star mergers

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Both coherent and incoherent low-frequency radio emission are predicted at various timescales when neutron stars coalesce. In this talk, I show how the Low-Frequency Array (LOFAR) is being used to catch both fast and slow radio transients related to neutron star mergers.

At the earliest timescales, coherent emission resembling FRBs is predicted by several theoretical models. Testing these models can shed light on the nature of the merger remnant and other important questions, but requires rapid triggered observations. We use LOFAR's rapid response mode to trigger on short gamma-ray bursts (SGRBs) detected by *Swift*, which have neutron star merger progenitors. This enables us to be on source within minutes and to probe early-time coherent emission at unprecedented sensitivity thanks to the long dispersive delays afforded at 144 MHz. Here, I present our strategy and latest results using joint LOFAR and *Swift* X-ray and gamma-ray data.

In addition to possible prompt emission, there will be a long-lasting synchrotron afterglow caused by the merger ejecta's interaction with the ambient medium. The afterglow contains a wealth of information including the geometry and energy of the merger outflow. The biggest challenge associated with detecting the electromagnetic counterpart of gravitational wave (GW) merger events, however, is the large uncertainty (tens of square degrees) on their locations. Here, we present our strategy which applies LOFAR's high sensitivity and large field of view to search for GW merger radio counterparts. In particular, using state-of-the-art data reduction techniques, we obtain radio maps covering 21 deg^2 with rms noise levels down to 0.2 mJy on epochs ranging from 1 week to months post-merger. We present our results from LOFAR follow-up observations of three merger events from the last GW observing run. We also show how the high sensitivity, large field of view and range of epochs permit us to probe previously unexplored parts of general radio transient phase space. Finally, the wide coverage of our observations should probe most of the localization region for binary neutron star merger events detected in the next GW observing run.