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Terrestrial drivers of rapidly changing plasma structures observed with the International LOFAR Telescope

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The Low Frequency Array (LOFAR) is designed to observe the early universe at radio wavelengths. When radio waves from a distance astronomical source traverse the ionosphere, structures in this plasma affect this signal. The high temporal resolution available (~100 ms), the large range of frequencies observed (10-80 MHz & 120-240 MHz) and the large number of receiving stations (currently 52 across Europe) mean that LOFAR can observe the effects of the midlatitude ionosphere in an unprecedented level of detail.

On the 14th July 2018 LOFAR stations across the Netherlands observed Cygnus A between 17:00 UT and 18:00 UT. At approximately 17:40 UT, station RS508 (53.24^{o} N; 6.95^{o} E) recorded a deep fade in the intensity of the received signal, lasting some 15 minutes. Immediately before and after this deep fade rapid variations of signal strength were observed, lasting less than five minutes. Frequency dependent behavior was observed. This feature was also observed using other LOFAR stations across the Netherlands, at slightly different times and with a slightly different structure. Collectively these observations allow the determination of the velocity and altitude of the plasma structure causing these variations in signal strength. It is shown that this is in the ionosphere, and the evolution of this structure in time and in space is determined.

The geomagnetic conditions at the time of the observation were quiet, as were the solar conditions. It is suggested that this structure is driven by a source within the Earth system. Observations from lower in the atmosphere are used to identify possible drivers.