EGU21-14435
https://doi.org/10.5194/egusphere-egu21-14435
EGU General Assembly 2021

Needle properties and a new higher altitude negative leader structure; observations by the LOFAR radio telescope

Brian Hare[1], Olaf Scholten[1], Joseph Dwyer[2], Liu Ningyu[2], Chris Strepka[2], and the LOFAR CR KSP[*]
[1]University of Groningen, Kapteyn Astronomical Insititute, Netherlands (b.h.hare@rug.nl)
[2]Department of Physics and Space Science Center (EOS), University of New Hampshire, Durham NH 03824 USA
[*]A full list of authors appears at the end of the abstract

Recently, Hare et al. 2020 found that individual leaders steps could be imaged in the VHF band, and for leaders below 5 km altitude, the radio emission from each step is mostly consistent with a point-source. We will report on new observations of negative leaders above 7 km altitude that behave significantly differently than lower altitude leaders. These higher- altitude leaders are a few 100 meters wide and have step lengths a few 100 meters long, as opposed to lower altitude leaders that are at most 10 meters wide with 10 meter stepping lengths. Furthermore, unlike lower altitude leaders, the radio emission from individual steps of higher altitude shows extensive structure. Each step shows a burst of radio radiation, followed by the growth of multiple filamentary structures. The nature of these filaments is presently unclear, but they could be long streamers or leader branches. We have observed one leader that clearly starts at low altitude and propagates to higher altitude. This leader shows that the transition from the low altitude mode of propagation to the higher altitude mode does not occur smoothly as one may expect, but occurs abruptly at around 6 km altitude within only one kilometer, somewhat similarly to a phase change.

Previous work has measured 100 m long stepping lengths of higher altitude leaders, and it is often assumed that this is a simple pressure scaling effect. However, our data shows that the stepping process at lower altitudes and higher altitudes appears very differently in VHF, and that the transition between the two modes occurs rapidly. This implies higher and lower altitude leaders actually have different propagation modes, and are not merely pressure-scaled versions of each other.

We will also present new detailed VHF measurements of needle activity. We will show that needle twinkles have a wide range of propagation speeds, from 10^5 to 10^7 m/s, and that needle twinkles sometimes show stepping behavior, which strongly implies that needle twinkles can propagate similar to stepped leaders or dart leaders depending on the conductivity of the needle. We will also show that recoil leaders can quench needle activity, which leads to a cycle of increasing needle activity followed by quenching by a recoil leader, as originally predicted by Hare et al. 2019.

LOFAR CR KSP: S. Buitink A. Corstanje H. Falcke J.R. Horandel T. Huege G.K. Krampah P. Mitra K. Mulrey A. Nelles H. Pandya J.P. Rachen S. Thoudam T.N.G. Trinh S. ter Veen T. Winchen