URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Simulating Interferometry Images of Lightning

Ningyu Liu*[(1)], Joseph Dwyer[(1)], Chris Sterpka[(1)], Olaf Scholten[(2)], Brian M. Hare[(2)], and Julia Tilles[(3)]
(1) University of New Hampshire, New Hampshire, USA
(2) University of Groningen, Groningen, Netherlands
(3) Sandia National Laboratory, New Mexico, USA

Recent broadband high-frequency radio interferometer observations have provided critical insights into the physics of lightning and other thunderstorm electrical discharges [1-4]. With the data collected by large radio telescope arrays like LOFAR, it becomes possible to image lightning processes at meter-scale and nanosecond resolution [2]. Interpreting the interferometry images is, however, not a trivial task. The main discharge components of lightning that generate high-frequency electromagnetic radiation are believed to be small-scale streamers. For any process of lightning that emits bursts of high-frequency radiation, many streamers are expected to participate, with the extreme case of over ten million of them [5]. Therefore, the lightning radiation source that is imaged by the radio interferometer can be very complex, and careful interpretation of the images is required.

In this work, we take a forward approach to understand the interferometry images of lightning. The electromagnetic radiation from synthetic streamer systems is calculated and fed into a model radio interferometer. Radio images of the synthetic sources are then constructed by using the data collected by the interferometer. We will report the imaging results of synthetic streamer systems with varying temporal and spatial properties by using two different imaging techniques: a cross-correlation based method and a phase shift and sum method. We will also discuss how the beamforming technique enables imaging of the synthetic sources at higher resolution.

References

[1] Rison,W., Krehbiel, P. R., Stock, M. G., Edens, H. E., Shao, X.-M., Thomas, R. J., et al. (2016). Observations of narrow bipolar events reveal how lightning is initiated in thunderstorms. Nature Communications, 7, 10721.

[2] Hare, B., Scholten, O., Dwyer, J., Trinh, T., Buitink, S., ter Veen, S., et al. (2019). Needle-like structures discovered on positively charged lightning branches. Nature, 568(7752), 360–363.

[3] Tilles, J., Liu, N., Stanley, M. A., Krehbiel, P. R., Rison,W., Stock, M. G., et al. (2019). Fast negative breakdown in thunderstorms. Nature Communications, 10, 1648.

[4] Pu, Y., & Cummer, S. A. (2019). Needles and lightning leader dynamics imaged with 100–200 MHz broadband VHF interferometry. Geophysical Research Letters, 46, 13,556–13,563.

[5] Liu, N., Dwyer, J. R., Tilles, J. N., Stanley, M. A., Krehbiel, P. R., Rison,W., et al. (2019). Understanding the radio spectrum of narrow bipolar events. Journal of Geophysical Research: Atmospheres, 124, 10,134–10,153.