Measuring self-induced corona discharges of individual aerosol particles in an optical trap as a potential mechanism for lightning initiation

A. Stoellner[a], I.C.D. Lenton[b], C. Muller[a] and S.R. Waitukaitis[a]

[a]*Institute of Science and Technology Austria, Klosterneuburg 3400, Austria*
[b]*University of Manchester, Manchester M13 9PL, United Kingdom*

Although cloud electrification and lightning have been studied for hundreds of years, the field still deals with many open questions [1]. One of the most puzzling examples is that of lightning inititation – neither the mechanism by which a cloud generates enough charge to cause lightning nor the process by which lightning itself is triggered are well understood. In our experiment we aim to gain insight into both questions on the scale of a single particle. We utilize optical tweezers to levitate individual aerosol particles and observe their charging and discharging dynamics over days-to-weeks time periods and with elementary-charge resolution. Our approach allows us to study these processes without losing information to ensemble averages or external interference from other particles or substrates [2], and is applicable to solid and liquid particles in the micrometer size range. Using multi-photon absorption from the trapping laser [3] we can charge the trapped particle at different rates and to different values, observing every charging and discharging event along the way. Additionally, the experiment allows us to control the relative humidity around the particle and to fully discharge the particle using air ions. By studying the charging behavior of the particle and the spontaneous discharges it experiences, we hope to contribute to a better understanding of the microphysical processes involved in lightning initiation and adjacent electrical phenomena in the atmosphere.

This project has received funding from the European Research Council (ERC) under the European Union's Starting Grant (A. Stoellner, I. Lenton & S. Waitukaitis received funding from ERC No. 949120, C. Muller received funding from ERC No. 805041).

[1] J. R. Dwyer and M. A. Uman, Physics Reports 534, 147 (2014).
[2] F. Ricci, M. T. Cuairan, G. P. Conangla, A. W. Schell, and R. Quidant, Nano Letters 19, 6711 (2019).
[3] A. Ashkin and J. M. Dziedzic, Physical Review Letters 36, 267 (1976).