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Selected personal highlights from experimental space studies of the aurora (Hannes Alfvén Medal Lecture)

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Aurora is a most spectacular and frequently occurring scenery in the winter polar sky, occurring on Earth and many other planets. To further our understanding of the physics of the aurora, numerous sounding rocket and satellite projects have been carried out since the 1960's. Results are presented for a small selection of these where the author and his research team at KTH were strongly engaged in the research, namely a series of rocket experiments and small satellite missions, and the European Space Agency Cluster multi-satellite mission. The electric field plays a fundamental role in the physics of the magnetosphere and of the aurora, such as for the acceleration of electrons and ions producing bright aurora and outflow of energetic plasma. The results include: An arc classification scheme based on the electric field variation across arcs; A method to derive global distributions of electrodynamical parameters for a given auroral oval distribution; The discovery of intense diverging electric fields and of their characteristics in the auroral downward current region; Using Cluster data to reveal how such diverging electric fields evolve in time and are closely tied to the formation of ionospheric density cavities; Reconstruction of an experimentally verified acceleration potential pattern of the aurora, being stable on a 5 min time scale. Finally, acceleration signatures and electrodynamics of large-scale auroral forms, such as spirals, surges, and polar boundary intensifications are discussed based on recent Cluster and DMSP satellite conjunctions.