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Issues of onset in space plasma activity (Hannes Alfvén Medal Lecture)

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Advances in space plasma dynamics have led to a picture in which major phenomena such as the magnetospheric/ionospheric substorm are viewed as the interplay of a number of processes of a more elementary nature (elements), details depending on the selected focus. The lecture first gives a brief characterization of a set of substorm elements, among them energy transfer into and release from the magnetotail, formation of thin current sheets, magnetic reconnection, current wedge, ballooning instability and auroral phenomena. (This list does not devaluate the classical substorm phases, but a subdivision is called for.) A detailed picture based on observation, theory and simulation, which is required to fully disentangle the interaction of substorm elements, is not yet available. Several aspects that did become reasonably clear in recent times are reviewed. It seems that some of the substorm elements have their own onset scenarios, so that the popular notion of a single substorm onset mechanism needs to be reconsidered. Regarding energy release from the magnetotail, linear stability analysis and numerical simulations point at a crucial role of breakdown of electron gyrotropy leading to instability for sufficient stretching of the magnetotail. The onset of that instability is to be distinguished from the onset of magnetic reconnection. The occurrence of the ballooning instability is discussed in terms of magnetic flux tube entropy. Several interpretations exist about the onset of the instability of the stretched tail. Particular attention is paid to diverging views about causation. To what extent is the ongoing cause-and-effect debate on substorm dynamics based on differences in authors' intuition rather than on irrefutable facts?