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Field-aligned beams upstream of the Earth's bow shock: current observational knowledge and unresolved issues

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Space plasma shocks are an important source of charged particle energization throughout the cosmos, and the best-studied examples are at the Earth's bow shock. While the basic empirical picture has been known for some time, fundamental questions about the underlying mechanisms have resisted a comprehensive explanation in the case of field-aligned beams. This review talk will begin with an overview of the observational framework, including recent refinements in the characterizations of upstream field-aligned beams (FABs). Cluster data have also revealed a possible link between ring distribution particles within the foot of supercritical shocks and FABs, as well as the occurence of a very sharp boundary separating FABs and gyrating ion populations in the foreshock. The Wind spacecraft has seen FABs at distances in excess of 80 R_E from the Earth, indicating lifetimes greater than expected from linear theory of the ion-ion streaming instability. These observations prompt new questions. Some analytic calculations will be reviewed briefly, as these point to important possible production mechanisms. However, while simple kinematic models have long ago been shown to fit some of the data, they often fail to to predict the observations.