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Introducing log-kappa distributions for solar wind analysis

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The one-point probability density functions (PDFs) obtained from the Wind spacecraft observations of the magnitude of total magnetic field (B) and the solar wind quasi-invariant (QI) are investigated at 1 AU during the years 1995 and 1998. It is known from previous studies that the distributions follow in a rather good approximation a lognormal distribution. This indicates that the underlying random multiplicative processes are skewed, the PDFs are nonsymmetric. The concept of kappa distributions generating PDF tails closer to the observed values is introduced. The skewness, characteristic for the multiplicative processes in the solar wind, is treated on the basis of log-kappa distributions, introduced here for the first time.

Normal and lognormal distributions are related in a similar way to each other as the kappa and log-kappa distributions, although the statistics is based on extensive physics in the former and nonextensive physics in the latter cases. We show hat log-kappa PDFs describe the observed distributions in the solar wind more accurately than the lognormal PDFs. In particular, the tails of PDFs corresponding to extreme values of the considered parameters B and QI are better modeled in terms of the nonextensive approach. It indicates that, for the theoretical explanation of the complexity of multisource fluctuations present in 1 year solar wind magnetic and plasma data, both the extensive and the nonextensive physical escription is needed. The variation of the values of kappa obtained from the log-kappa fits can serve as a quantitative measure describing the changing balance between these two distinct physical processes during the solar cycle.