The Spatial and Spectral Distributions of Solar Flare Ions from Extreme Ultraviolet Spectroscopy

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During a solar flare, a large fraction of the released energy goes into accelerating electrons, detected via keV X-ray observations. In the majority of flares, proton and heavy ion velocity distributions are unknown due to a lack of MeV gamma-rays. For the first time in solar flare physics we use non-Gaussian line fitting of solar flare extreme ultraviolet (EUV) spectral lines to infer the properties of heavy ion populations during flare SOL2014-03-29T17:44, using the Hinode EUV Imaging Spectrometer (EIS). Suitable Fe XVI (262.976 Å, 3 MK) and Fe XXIII (263.766 Å, 15 MK) lines are fitted with a convolved kappa-Gaussian function, that accounts for both the EIS instrumental broadening and physical line profiles produced by non-thermal (or multi-thermal) ion populations. Many non-Gaussian Fe XVI and Fe XXIII line profiles are confidently observed during SOL2014-03-29T17:44. For Fe XXIII, the lowest kappa index values (κ~4) are observed close to coronal X-ray sources, with κ values between 4 and 9 at different flare times. Overall, the kappa indices for Fe XVI are smaller than those for Fe XXIII (κ~3-5), and they are located closer to ribbon and hard X-ray footpoint regions. The causes of non-Gaussian line profiles such as non-thermal ion motions (flare accelerated ions or turbulent plasma motions) and multi-thermal plasma are discussed, as well as the possibility of a non-Gaussian instrumental response.

Figure 1: Example of Fe XVI and Fe XXIII line fits during solar flare SOL2014-03-29T17:44, comparing both convolved kappa-Gaussian (KG1) and single Gaussian fitting.