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Acceleration and transport modeling of solar energetic particle charge states in impulsive events: a case study

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Measurements of the mean ionic charge of Fe showed for many ^{3}He-rich and Fe-rich solar energetic particle (SEP) events a strong energy dependence with a steep increase of the mean ionic charge of Fe from $\sim$14-16 at $\sim$0.2 MeV/nuc to $\sim$18-20 at $\sim$0.5 MeV/nuc. We selected the 1998 September 9 event for a detailed comparison of intensity-time profiles, energy spectra, and energy dependent charge states of Fe with an acceleration and transport model. We have investigated this event by fitting Wind and ACE observations using an acceleration model that includes stochastic acceleration, diffusion and charge stripping near the Sun, followed by particle transport in the interplanetary medium, taking account of particle focusing, pitch-angle scattering, adiabatic deceleration and convection. The simulation provides a reconstruction of the injection function of the energetic particles released from the Sun and their time, energy and charge dependence. We find that electrons and Fe ions are injected almost impulsively, whereas the injection of protons takes place on a much longer time scale, or even consists of two distinct injection processes. We are able to obtain good overall fits to the observations. This suggests that our model can be used to obtain information about the conditions in the acceleration region such as density, temperature and the time scales of the acceleration process, if sufficiently accurate modeling of the particle transport in the solar wind is possible.