INTRINSIC ENERGY CUT-OFF IN DIFFUSIVE SHOCK ACCELERATION: POSSIBLE REASON FOR NON-DETECTION OF TEV-PROTONS IN SNR'S

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The theory of shock acceleration predicts the maximum particle energy to be limited only by the acceleration time and the size (geometry) of the shock. This led to optimistic estimates for the galactic cosmic ray energy achievable in the SNR shocks. The estimates imply that the accelerated particles, while making *no strong impact on the shock structure* (test particle approach) are still scattered by *strong self-generated* Alfven waves (turbulent boost) needed to accelerate particles quickly. These two assumptions are, however, in conflict when applied to SNRs of the age required for cosmic ray acceleration to the "knee" energy.
We study the *combined* effect of acceleration nonlinearity (shock modification by accelerated particles) and the turbulent boost of acceleration on the maximum energy achievable by this mechanism in a given time. We show that the refraction to shorter wave lengths in the nonlinearly modified flow causes enhanced losses of particles in the momentum range $p_{max}/R < p < p_{max}$, where $R > 1$ is the nonlinear pre-compression of the flow and p_{max} is the absolute maximum momentum that could be reached in an unimpeded (linear, but turbulently boosted) acceleration process. The particle spectrum behaves as $p^{-\sigma} e^{-\sqrt{p/\overline{p}}}$at $p > p_* \equiv p_{max}/R$ as opposed to the conventional power-law $p^{-\sigma}$ at $p < p_*$. Since R itself is proportional to p_* that characterizes the energy content of accelerated particles (since $\sigma < 4$) the observationally important spectral break p_* should grow slower than $\sqrt{p_{max}}$. Moreover, due to the lack of particles at p_{max} (and thus waves in resonance with them) caused by the spectral break at $p_* = p_{max}/R$, the $p_{_{max}}(t)$ itself should advance much slower in time than the estimates based on the Bohm diffusion would predict. These nonlinear mechanisms of momentum limitation may result in significant reduction of both the absolute maximum momentum p_{max} and the observationally more impotant spectral break p_*.