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Stochastic re-acceleration in the ICM

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Abstract. Here we suggest that efficient stochastic particle re–acceleration in galaxy clusters may be driven by compressible modes. The damping of these modes is severely dominated by the TTD–resonance with thermal electrons and protons in the ICM. However, a small energy flux of these modes may be channelled into particle re-acceleration and this gives re-acceleration times of the order of $\sim 10^8$ yrs, sufficient to mantain GeV radiating electrons in the ICM.

Keywords. acceleration of particles, turbulence, galaxies: clusters: general

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The Mpc-scale radio non-thermal emission detected in a growing number of galaxy clusters (GC) proves the presence of GeV radiating electrons (e.g., Feretti 2005). In addition, relativistic hadrons should accumulate in GC and direct measurements of the hadronic content may come from future γ-ray observations (e.g., Blasi 2004). The origin of the radio emitting electrons in GC is still a matter of debate – they may either be re-accelerated or secondary particles originating from hadronic collisions (e.g., Brunetti 2004; Sarazin 2004). Present observations seem to favour the first scenario, but the role of future radio and γ-ray observations remains crucial. Detailed calculations of particle-turbulent mode coupling in the framework of this scenario were restricted to the case of the Alfvén modes, since they channel the bulk of their energy flux into acceleration of relativistic particles (Brunetti *et al.* 2004; Brunetti & Blasi 2005). On the other hand, unless these modes are injected at small scales (e.g., Lazarian & Beresnyak 2006), they develop an anisotropic cascade and this makes the acceleration process less efficient (Yan & Lazarian 2004). An additional possibility comes from the action of compressible modes injected in GC during cluster-cluster mergers. Here turbulence is sub-sonic but strongly super-Alfvénic so that the bending of the magnetic field lines actually limits the particle mean free path. This implies that the dissipation of turbulence happens via collisionless dampings preferentially on thermal electrons and protons. However, fast modes and magnetosonic waves also couple with relativistic particles via TTD-resonance and non-resonant turbulent compression. In the case of hot GC, we find that the acceleration time is $\sim 10^8(\frac{V_o}{c_s}/0.5)^3/(L_o/300\,\mathrm{kpc})\,\mathrm{yr}$, V_o being the rms velocity of magnetosonic modes at the max scale L_o, and c_s the sound speed. Thus, if the bulk of turbulence in GC is in the form of compressible modes, stochastic particle re-acceleration may maintain the GeV radiating particles.

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