lecture 4. astroparticle transport in magnetic fields

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Advanced Astroparticle Physics

NPAC M2

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in today's class...

- **motion of an ensemble of particles in magnetic fields**
- **cosmic-ray diffusion in the galaxy**
  - the leaky box model
  - the B/C ratio

magnetic fields

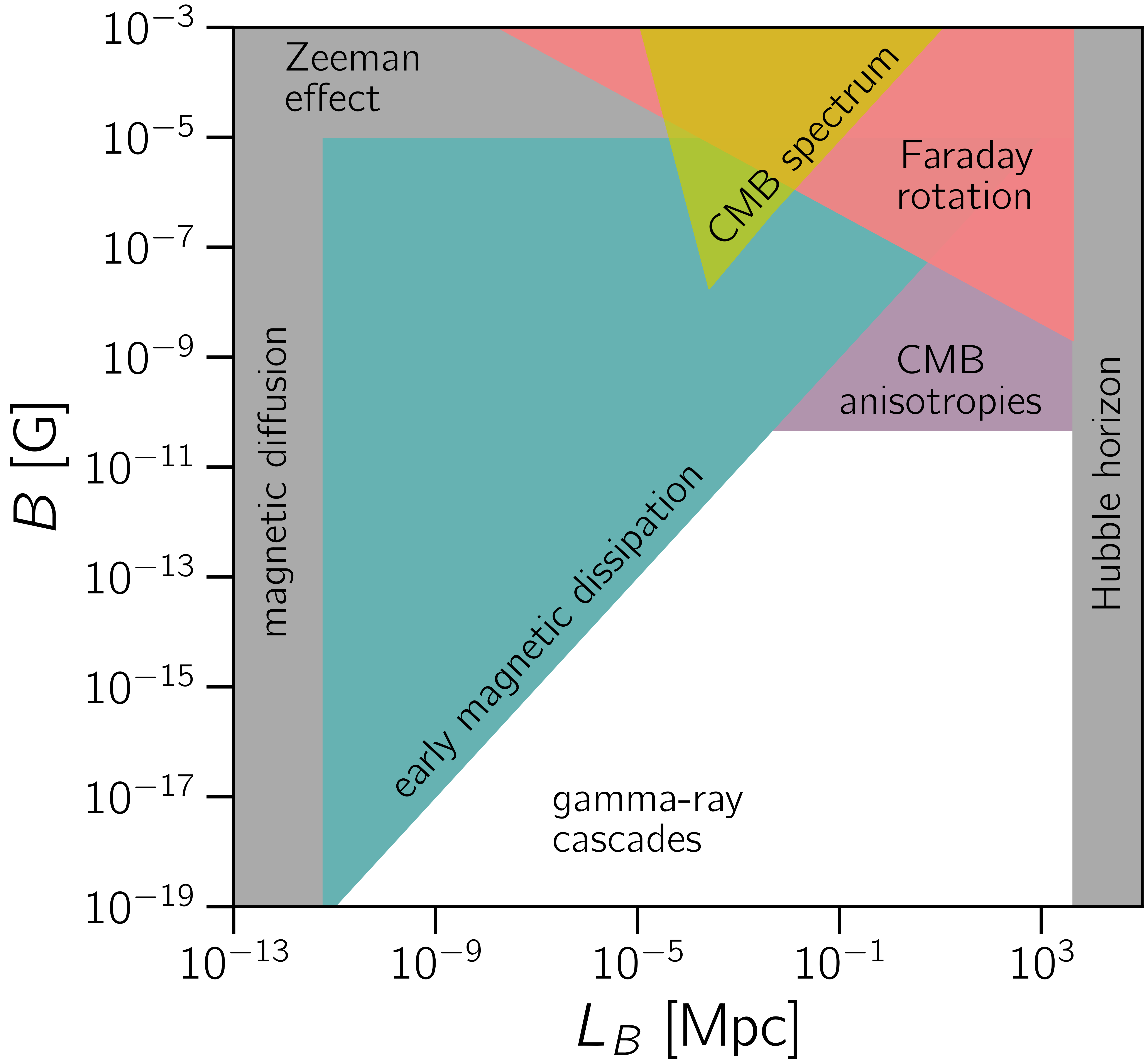
intergalactic magnetic fields

fundamental questions

- how were they produced?
- what is their role in the evolution of the universe?
- how strong are they?
- what is their power spectrum?
- what are their topological properties?

- **astrophysical mechanisms:** during structure formation (e.g. Biermann battery, …)
- **primordial mechanisms**: large-scale cosmological processes such as inflation, EW phase transition, QCD phase transition, …

intergalactic magnetic fields



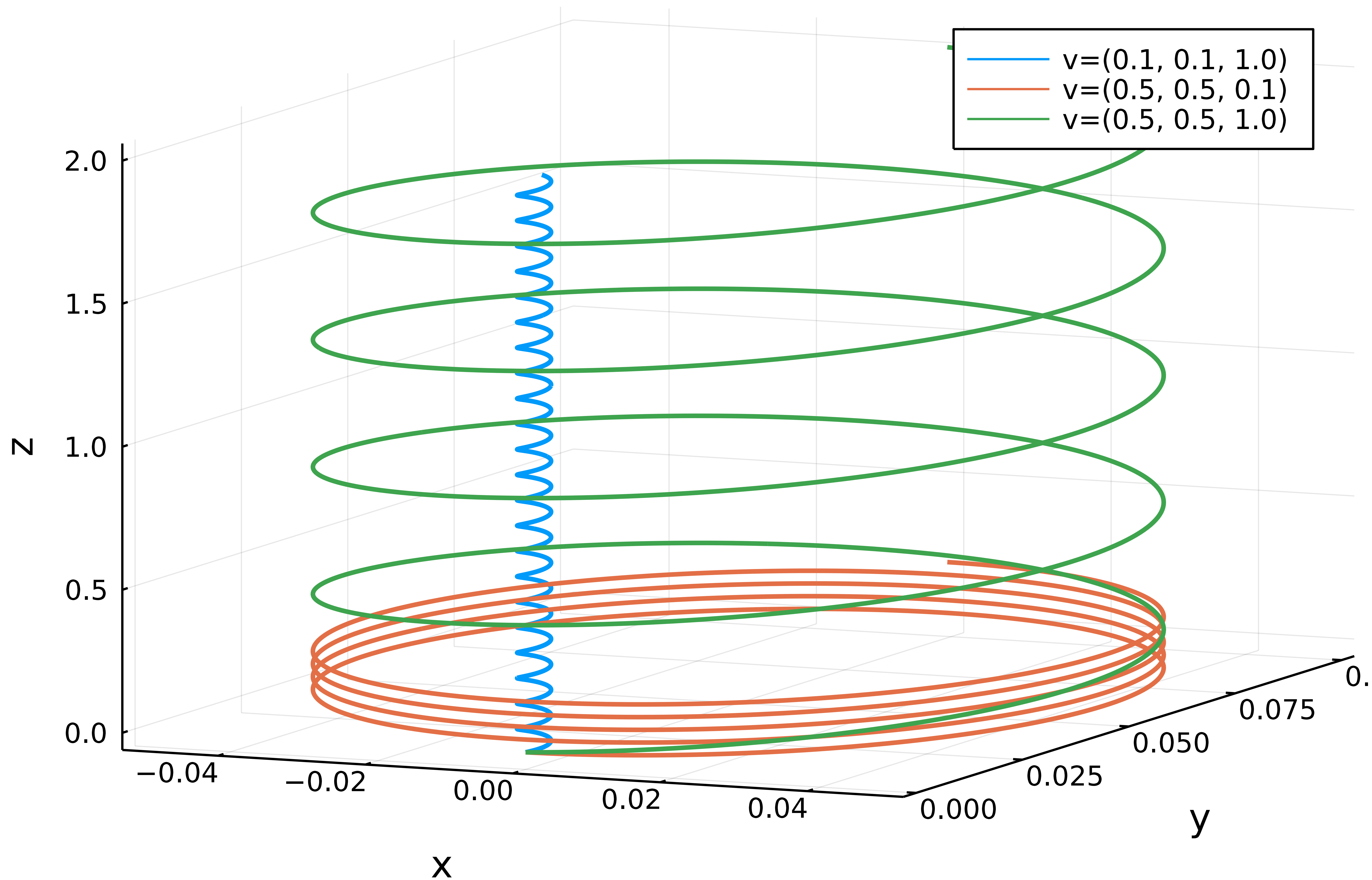
Alves Batista & Saveliev. Universe 7 (2021) 223. arXiv:2105.12020

properties of stochastic magnetic fields

- magnetic fields are usually approximated by a superposition of (nearly-)stochastic components
- **strength**: $B^2 \equiv B_{\mathrm{rms}}^2 = \frac{1}{V} \int\limits_V \left| \vec{B}(\vec{r}) \right|^2 \mathrm{d}^3 r$
- **power spectrum**: $M_k \propto k^{\alpha_B - 1}$
- **coherence length**: $L_B = \frac{2\pi \int k^{-1} M_k \,\mathrm{d}k}{\int M_k \,\mathrm{d}k}$
- **helicity**: $H_B = \int\limits_V \vec{A}(\vec{r}) \cdot \vec{B}(\vec{r}) \,\mathrm{d}^3 r$
- **structure of the field**

- in principle, none of these properties are necessarily small, such that all of them need to be taken into account in the models

particle propagation in homogeneous magnetic fields



CR escaping the intracluster medium