the collaboration project for **Cluster Subgroup**:

"Turbulence, Magnetic fields, and Particle Acceleration in High beta Intracluster Medium"

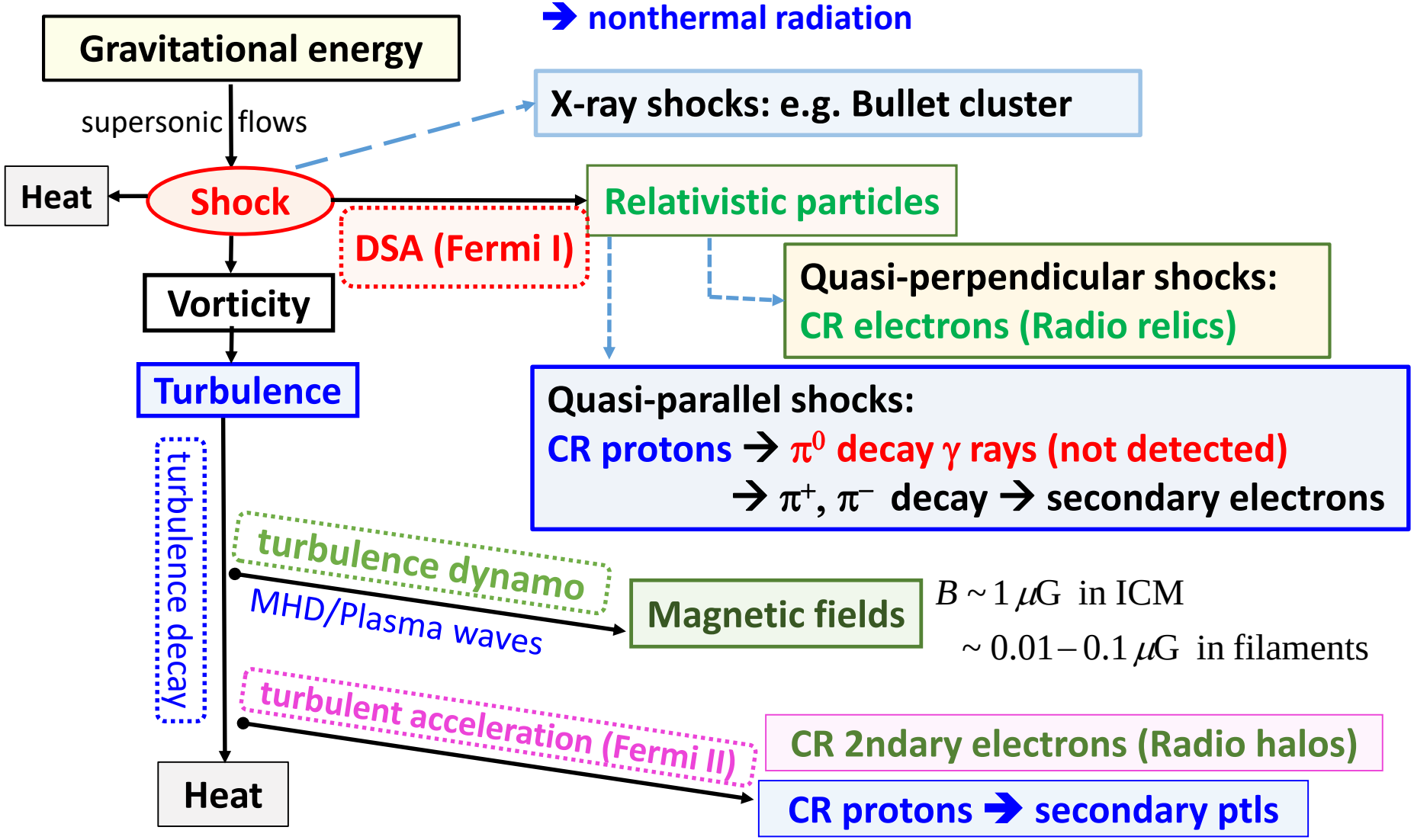
Aim: to understand MHD/plasma processes in high beta ICM

Member: Cho, Hur, Kang, Ryu, Roh, van Marle, Kim (new postdoc), Ha (J), Ha (S)

Problems to explore

1. Turbulence dynamo in stratified clusters: MHD simulations – Roh, Ha (S), Ryu, Cho
2. Effects of turbulence on the polarization of synchrotron emission behind the shock – Cho, Ryu
3. Transport of Alfven waves across MHD shocks – Kang, Ryu, Ha (J)
4. Damping of Alfven waves in the presence of P_{CR} gradient : MHD+CR simulations – Kang, Ryu, +
5. Injection process of CR particles to Fermi I acceleration at weak shocks : PIC sim. – Ha (J), Ryu, Kang
6. Fermi I acceleration at weak shocks: MHD+PIC sim. – van Marle, Ryu, Kang
7. EM radiation in PIC simulations: Langmuir radiation from PDO (plasma dipole oscillation) for FRB: PIC sim. – Hur, Ryu, Kim

Key Physical Processes in ICM: shocks, turbulence, magnetic fields, particle acceleration → nonthermal radiation



Non-detection of gamma-ray emission from galaxy clusters
→ revision of DSA efficiency at weak shocks in high beta plasma?

The acceleration of cosmic rays in shock fronts – I Bell 1978

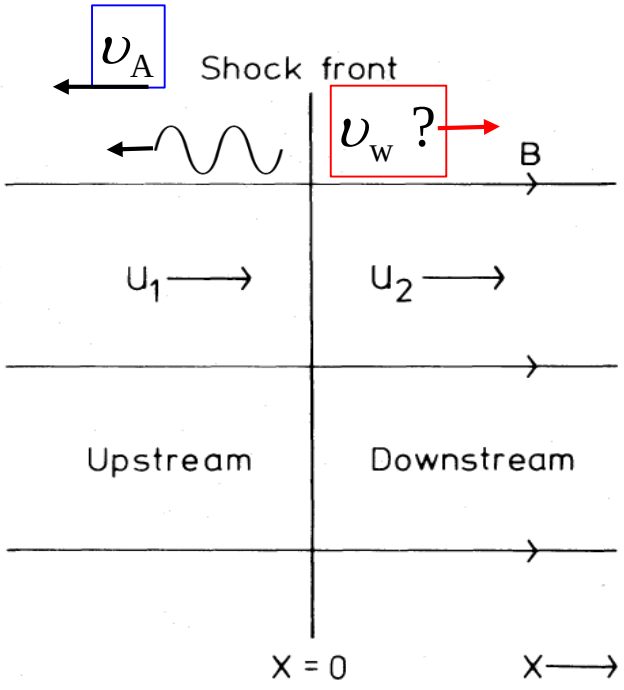
CR transport equation: Fokker-Planck Equation

$$\frac{\partial \bar{f}}{\partial t}+\frac{\partial}{\partial p^3}(p^3\mathbf{u}).\nabla \bar{f} = (\nabla.\mathbf{u})\,p^3\frac{\partial \bar{f}}{\partial p^3}+\nabla.(D_{\parallel}\mathbf{nn}.\nabla \bar{f})+\frac{\partial}{\partial p^3}\left(9p^4 D_{pp}\frac{\partial \bar{f}}{\partial p^3}\right) \quad (9)$$

Skilling 1975

$$\mathbf{u} = \mathbf{v}_0+\left\langle\frac{3}{2}(1-\mu^2)\frac{\nu_+-\nu_-}{\nu_++\nu_-}\right\rangle v_A\mathbf{n}$$

= flow speed + Alfvenic drift



u_1, u_2 : mean velocities of scattering centers

$$u_1 = v_s - v_A, \quad u_2 = \frac{v_s}{\chi} + v_w$$

χ = gas compression ratio

v_A = Alven wave speed

v_w = mean velocity of scattering centers

$$N(E)\,dE = \frac{\mu-1}{E_0}\left(\frac{E}{E_0}\right)^{-\mu}dE$$

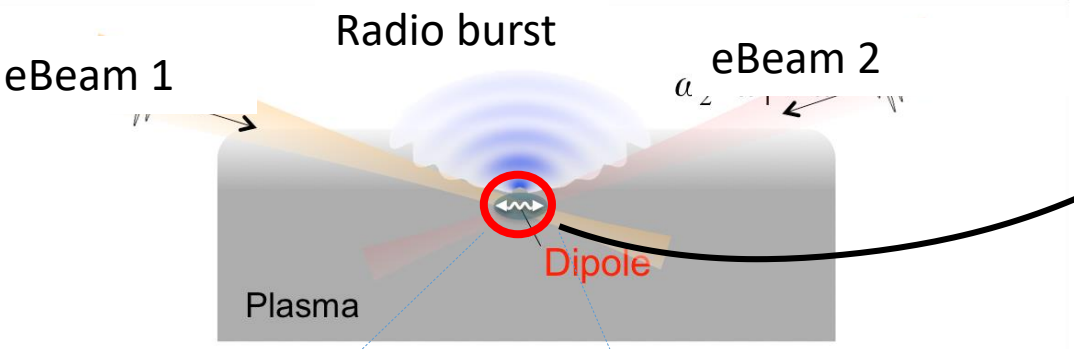
energy spectrum

$$\mu = \frac{(2+\chi)}{(\chi-1)}$$

slope

Alfvenic drift may steepen the CR energy spectrum.
➔ may reduce the CR proton acceleration efficiency.
But not seen in PIC/Hybrid simulations yet.

PDO by Trapped Particles

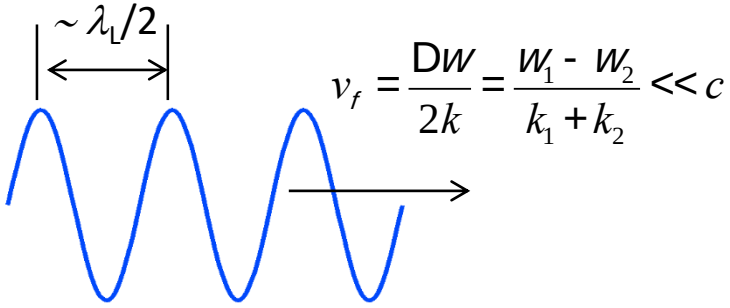


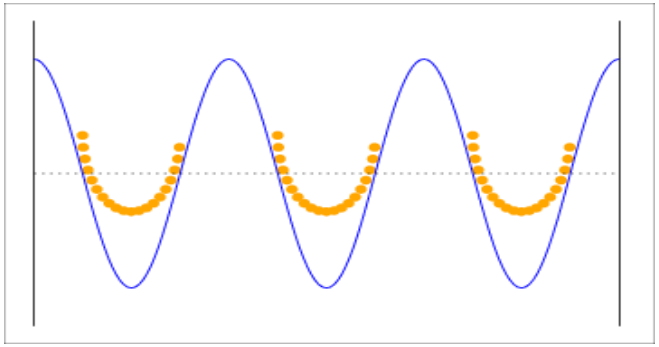
Moving Potential Train

$$F_{PM} \sim I_{laser} e^{2ikz - i\Delta\omega t}$$

$$\Delta\omega = \omega_1 - \omega_2 << \omega_{1,2}$$

$$2k \circ k_1 + k_2$$





Electrons riding on the potential train are displaced in a block to the right

Velocity of the displacement is determined by the laser detuning $\Delta\omega$