Mode-particle Interactions
as Sources of Gamma-ray Bubbles in the Galaxy*

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A plasma outflow coming from the center of Our Galaxy is simulated by an ion beam reaching a nearly stationary magnetic field that can excite lower hybrid waves efficiently in the rarefied plasma (10^{-2}-10^{-4} cm^{-3}) surrounding the whole galaxy. The electrostatic lower hybrid waves are driven to instability via Cerenkov interaction. In this work we derive (by using a fluid model) the relevant dispersion relation and the expression for the growth rate by solving the dispersion relation both analytically and numerically. Parametric studies show that the growth rate of the instability increases with the beam density. The instability is found to have the maximum growth rate when the perpendicular phase velocity of the lower hybrid mode is comparable to the velocity of the beam, and the parallel phase velocity is comparable to electron thermal velocity. Since the growth rate is maximum when the parallel-wave phase velocity of the lower hybrid wave is of the order of the electron thermal velocity, we expect efficient energy transport from the perpendicular ion beam to the bulk of the electrons via Landau damping, accelerating the electrons, of the plasma surrounding the galaxy, or heating them. The radiation emission due to this energetic electron component could explain the observed x and gamma-ray spectra (Fermi bubbles) [1]. *Sponsored in part by the U.S. Department of Energy and by C.N.R of Italy.

[1] H.-Y. K. Yang, M. Ruszkowski, E.G. Zweibel, Galaxies **6,** 29 (2018).