Interactions of positron acoustic solitary waves and phase shifts in multi-component plasma


1Department of Applied Mathematics, University of Rajshahi, Rajshahi-6205, 2Department of Mathematics, CUET, Chittagong, 3Plasma Science and Technology Lab, Department of Applied Physics and Electronic Engineering, University of Rajshahi, Rajshahi-6205, Bangladesh

*E-mail: golam_hafez@yahoo.com

It is well established that the electron-positron-ion (epi) plasmas are existed in astrophysical, space and laboratory plasmas for understanding the physical issues involved. Recently, Alam et al. [1] have studied the positron acoustic (PA) Korteweg-de Vries (KdV) solitary waves (SWs), modified KdV (mKdV) SWs, Gardner SWs, and double layers (DLs) in the epi plasmas composing immobile positive ions, mobile cold positrons, and superthermal hot electrons and hot positrons. But, the interactions with non-linear waves, including resonances, carry important physical phenomena as observed in space plasmas [2, 3]. This work investigates the interactions of PA waves (PAWs) in unmagnetized plasmas consisting of immobile positive ions, mobile cold positron, and superthermal hot positrons, and hot electrons. The normalized governing equations can be written [1] as

\[
\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x} \left( \rho u \right) = 0, \quad \frac{\partial u}{\partial t} + \frac{\partial}{\partial x} \left( u^2 + b \right) = - \frac{\partial p}{\partial x} - \frac{\partial \phi}{\partial x} - \epsilon \frac{\partial^2 \phi}{\partial x^2}.
\]

Here, \( n_{pc} \) is the cold positron number density normalized by its equilibrium value \( n_{pc0} \), \( u_{pc} \) is the cold positron fluid speed normalized by \( C_{pc} = \left( k_B T_{ef} / m_p \right)^{1/2} \), \( \phi \) is the electrostatic wave potential normalized by \( k_B T_{ef} / e \), \( \alpha_1 = T_{ef} / T_{ph} \), \( \alpha_2 = T_{ef} / T_e \), \( \mu_{ph} = n_{ph0} / n_{pc0} \), \( \mu_e = n_{e0} / n_{pc0} \), \( \mu = n_{i0} / n_{pc0} \), \( \gamma_{ph} = T_{ph} / (T_{ph} + \mu_{ph} T_e) \) is the effective temperature, \( k_B \) is the Boltzmann constant, \( m_p \) is the positron mass and \( e \) is the magnitude of electron charge. The time \( t \) is normalized by \( \omega_{pc}^{-1} = \left( m_p / 4 \pi n_{pc0} e^2 \right)^{1/2} \) and the space \( x \) is normalized by the Debye length \( \lambda_D = \left( k_B T_{ef} / 4 \pi n_{pc0} e^2 \right)^{1/2} \). To study the solitons collision, two-sided KdV and mKdV are derived using the extended PLK method [2]. The stationary solutions of the KdV equations is obtained as \( \phi^{(1)} = \phi_0 \text{sech}^2 \left( \frac{(x - \alpha) \omega}{\omega_0} \right) \) and the corresponding phase shifts after weak head-on collision between the KdV solitons \( \sqrt{p_0} = 2 \epsilon^2 \frac{D}{\alpha_0} \phi_0 W_0 \) and \( \sqrt{q_0} = 2 \epsilon^2 \frac{D}{\alpha_0} \phi_0 W_0 \), where \( \phi_0 = (3U_0 / A) \) and \( W_0 = \sqrt{(4A / U_0)} \) are the amplitude and width both of the right and left moving mKdV solitary waves in their initial positions, \( U_0 \) is the constant velocity of the reference frames, \( A = \frac{1}{2} \left( \frac{3}{2} R_2 \right)^{1/2} \), \( R_2 = \left( \frac{\mu_{ph}(x - \alpha)^2}{2(x - \alpha)^2} - \frac{\mu_{ph}(x - \alpha)^2}{2(x - \alpha)^2} \right) \).}

References