

























$$\left[ \alpha \partial_{\eta\eta}^2 - \left( \frac{Q^2 C}{6P'K} + 3P'Kb^2 \right) - 6\beta A^2 \operatorname{sech}^2 b(\eta - V\tau) \right] \Psi = \lambda \Psi, \quad (54)$$

or

$$[\alpha \partial_{\eta\eta}^2 - 6\beta A^2 \operatorname{sech}^2 b(\eta - V\tau)] \Psi = \lambda' \Psi, \quad (55)$$

$$\lambda' = \lambda + \frac{Q^2 C}{6P'K} + 3P'Kb^2.$$

The left-hand side of (55) is known to possess a single negative discrete eigenvalue, corresponding to the one soliton case, which immediately leads to a restriction on the admissible values for  $\lambda'$  and yields the condition for stability.

## 7. Discussion

In our analysis we have investigated the formation and propagation of solitary waves in a plasma, in which both the electrons and ions have been considered relativistic. Our analysis encompasses cases of both laboratory and space plasmas. Conditions for the modulational stability of envelope solitons have been investigated by a variational procedure. Lastly, it is demonstrated that the expression for the critical angle reduces to that of Kakutani *et al.* (1967).

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