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ERRATUM

Erratum to: Dust-acoustic solitary and rogue waves in a Thomas-Fermi degenerate dusty plasma

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In our original paper (Irfan et al. 2014), we have found that the KdV based nonlinear Schrödinger (NLS) equation does not satisfy the criteria of modulational instability (i.e., $PQ > 0$) and the existence of rogue waves, where P and Q are the dispersion and nonlinearity coefficients of NLSE. We therefore have made a remedy correction for this situation in this erratum and applied a well-known multiscale reductive perturbation method (Moslem et al. 2011) to fluid equations of Irfan et al. (2014), analyzing the rogue waves in a Thomas-Fermi dusty plasma. In the previous literature (El-Labany et al. 2012; Rahman et al. 2013; Rahman and Ali 2014; El-Awady and Moslem 2011; El-Awady et al. 2014; Panwar et al. 2013; Panwar and Ryu 2014; Bains et al. 2014 etc.), it was shown that the KdV based NLS Equation holds the condition $PQ > 0$ for the existence of rogue waves. However, it is later on realized (El-Tantawy and Moslem 2014) that the KdV based NLS equation does not admit the rogue waves, for which the product $PQ < 0$ holds. Thus, to use a multiscale reductive perturbation method, we consider the expansion $\mathbf{S} = \mathbf{S}_0 + \sum_{n=1}^{\infty} \varepsilon^n \sum_{l=-\infty}^{l=\infty} \mathbf{S}_l^{(n)}(\zeta, \tau) \exp(il\Theta)$ for dependent variables and the stretching $\zeta = \varepsilon(r - V_g t)$, and $\tau = \varepsilon^2 t$, where ε is a small expansion parameter, whereas $\mathbf{S}_l^{(n)} = [n_{dl}^{(n)}\ u_{dl}^{(n)}\ \phi_l^{(n)}]^T$, $\mathbf{S}_l^{(0)} = [1\ 0\ 0]^T$ and $\Theta = kx - \omega t$. The parameter k (ω) is the wave number (wave frequency) of the carrier waves. The coefficient $S_l^{(n)}$ must be real and can be taken as $\mathbf{S}_{-l}^{(n)} = \mathbf{S}_l^{(n)*}$. The asterisk designates the complex conjugate of $\mathbf{S}_l^{(n)}$.

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Applying the above stretching and expansions to Eqs. (7)–(12) of Irfan et al. (2014) and ignoring the transverse perturbations, we obtain for $n = 1$ and $l = 1$ as,

$$n_{d1}^{(1)} = \frac{-k^2}{(\omega^2 - k^2\sigma_d)}\phi_1^{(1)}, \qquad u_{d1}^{(1)} = \frac{-k\omega}{(\omega^2 - k^2\sigma_d)}\phi_1^{(1)} \tag{1}$$

and

$$\frac{\omega^2}{k^2} = \frac{1}{\frac{3}{2}(\mu_e\sigma_i + \mu_i) + k^2} + \sigma_d. \tag{2}$$

Here μ_e, μ_i, σ_i and σ_d are already defined in Irfan et al. (2014). The first harmonic perturbations in the second-order approximation, i.e., $n = 2$ and $l = 1$ can be expressed as

$$n_{d1}^{(2)} = \frac{ik}{\omega(\omega^2 - k^2\sigma_d)^2}\bigg\{\left(2\omega^3 - 2kV_g\omega^2\right)\frac{\partial\phi_1^{(1)}}{\partial\xi} + ik\omega\left(\omega^2 - k^2\sigma_d\right)\phi_1^{(2)}\bigg\}, \tag{3}$$

and

$$u_{d1}^{(2)} = \frac{i}{(\omega^2 - k^2\sigma_d)^2}\bigg\{ik\omega\left(\omega^2 - k^2\sigma_d\right)\phi_1^{(2)} + \left(\omega^3 - kV_g\omega^2 - k^3\sigma_d V_g + k^2\sigma_d\omega\right)\frac{\partial\phi_1^{(1)}}{\partial\xi}\bigg\} \tag{4}$$

the compatibility condition then leads to,

$$V_g = \frac{\partial \omega}{\partial k} = \frac{1}{k\omega}\{\omega^2 - (\omega^2 - k^2\sigma_d)^2\}. \tag{5}$$

Equation (5) represents the group velocity of the envelope dust-acoustic (DA) waves in a Thomas-Fermi dusty plasma.

The nonlinear self-interaction of the harmonic perturbations developed in the second-order approximation, i.e., $n = 2$ and $l = 0, 2$, comes out as,

$$\begin{aligned} &\phi_2^{(2)} = A(\phi_1^{(1)})^2, \qquad n_{d2}^{(2)} = B(\phi_1^{(1)})^2 \quad \text{and} \\ &u_{d2}^{(2)} = C(\phi_1^{(1)})^2. \end{aligned} \tag{6}$$

Similarly,

$$\begin{aligned} &\phi_0^{(2)} = D|\phi_1^{(1)}|^2, \qquad n_{d0}^{(2)} = E|\phi_1^{(1)}|^2 \quad \text{and} \\ &u_{d0}^{(2)} = F|\phi_1^{(1)}|^2, \end{aligned} \tag{7}$$

where

$$A = \frac{1}{\delta_1}\left\{3k^4\omega^2 + \frac{3}{4}(\mu_e\sigma_i^2 - \mu_i)(\omega^2 - k^2\sigma_d)^3\right\},$$

$$\begin{aligned} B = \frac{k^2}{\delta_1}\bigg\{&-\frac{9}{2}k^2\omega^2(\mu_e\sigma_i + \mu_i) \\ &-\frac{3}{4}(\mu_e\sigma_i^2 - \mu_i)(\omega^2 - k^2\sigma_d)^2 - 12k^4\omega^2\bigg\}, \end{aligned}$$

$$\begin{aligned} C = \frac{kw}{\delta 1}\bigg\{&-\frac{9}{2}k^2\omega^2(\mu_e\sigma_i + \mu_i) \\ &-\frac{3}{4}(\mu_e\sigma_i^2 - \mu_i)(\omega^2 - k^2\sigma_d)^2 - 12k^4\omega^2 - 2k^4 \\ &+ 8k^4(\omega^2 - k^2\sigma_d) + 3k^2(\mu_e\sigma_i + \mu_i)(\omega^2 - k^2\sigma_d)\bigg\}, \end{aligned}$$

$$\begin{aligned} D = \frac{1}{\delta_2}\bigg\{&-2k^3\omega V_g - k^2\omega^2 \\ &-\frac{3}{4}(\mu_e\sigma_i^2 - \mu_i)(V_g^2 - \sigma_d)(\omega^2 - k^2\sigma_d)^2\bigg\}, \end{aligned}$$

$$\begin{aligned} E = \frac{V_g}{\delta_2}\bigg[&\frac{3}{2}(\mu_e\sigma_i + \mu_i)\left(2k^3\omega + \frac{k^2\omega^2}{V_g}\right) \\ &+ \frac{3}{4V_g}(\mu_e\sigma_i^2 - \mu_i)(\omega^2 - k^2\sigma_d)^2\bigg], \end{aligned}$$

$$\begin{aligned} F = \frac{1}{\delta_2}\bigg[&-2k^3\omega\left\{\frac{3}{2}(\mu_e\sigma_i + \mu_i)(V_g^2 - \sigma_d) - 1\right\} \\ &+ \frac{3}{2}(2k^3\omega V_g^2 + k^2\omega^2 V_g)(\mu_e\sigma_i + \mu_i) \\ &+ \frac{3V_g}{4}(\mu_e\sigma_i^2 - \mu_i)(\omega^2 - k^2\sigma_d)^2\bigg], \end{aligned}$$

whereas

$$\begin{aligned} \delta_1 = 2(\omega^2 - k^2\sigma_d)^2\bigg\{&k^2 - \frac{3}{2}(\mu_e\sigma_i + \mu_i)(\omega^2 - k^2\sigma_d) \\ &- 4k^2(\omega^2 - k^2\sigma_d)\bigg\}, \end{aligned}$$

and

$$\delta_2 = (\omega^2 - k^2\sigma_d)^2\left\{\frac{3}{2}(\mu_e\sigma_i + \mu_i)(V_g^2 - \sigma_d) - 1\right\}.$$

The first harmonic in the third order approximation $n = 3$ and $l = 1$ leads to the following NLS equation as,

$$i\frac{\partial \Psi}{\partial \tau} + \frac{P}{2}\frac{\partial^2 \Psi}{\partial \zeta^2} + Q|\Psi|^2\Psi + i\frac{\Psi}{2\tau} = 0, \tag{8}$$

where the coefficients are, respectively, given by

$$\begin{aligned} P = {}& \frac{\partial V_g}{\partial k}\left(\equiv \frac{\partial^2 \omega}{\partial k^2}\right) \\ \equiv {}& \frac{1}{k^2\omega^2(\omega^2 - k^2\sigma_d)}\{-\omega(\omega^2 - k^2\sigma_d)^3 \\ &- k\omega V_g(3\omega^3 - 3kV_g\omega^2 - k^3 V_g\sigma_d + k^2\omega\sigma_d) \\ &+ k^2\sigma_d(2\omega^3 - 2kV_g\omega^2) \\ &+ \omega^2(\omega^3 - k\omega^2 V_g - k^3 V_g\sigma_d + k^2\omega\sigma_d)\}, \end{aligned} \tag{9}$$

and

$$\begin{aligned} Q = \frac{1}{2k^2\omega}\bigg[&\left\{\frac{3}{4}(\mu_e\sigma_i^2 - \mu_i)(A + D) - \frac{3}{16}(\mu_e\sigma_i^3 + \mu_i)\right\} \\ &\times (\omega^2 - k^2\sigma_d)^2 \\ &- k^2\omega^2(B + E) - 2k^3\omega(C + F)\bigg]. \end{aligned} \tag{10}$$

Where we assumed $\phi_1^{(1)} = \Psi$ for simplicity. Note that for nonplanar geometry, the forth term appears on the L.H.S. of Eq. (8).

The dispersion and nonlinearity coefficients (9) and (10) are numerically plotted against the equilibrium electron number density (n_{e0}) in Fig. 1. Since both P and Q are negative, therefore the condition $PQ > 0$ holds, and leads to the existence of DA rogue waves. For neglecting the nonplanar geometry effects, the solution of Eq. (8) gives rise to $\Psi = (P/Q)^{1/2}\{-1 + 4(1 + 2iP\tau)/(1 + 4P^2\tau^2 + 4\zeta^2)\}\exp(iP\tau)$ and is plotted in Fig. 2. It is important to notice that this solution is slightly different from the one studied earlier (Irfan et al. 2014; Abdelsalam et al. 2011; Moslem et al. 2011) which is compatible when the dispersion coefficient (P) is positive (Moslem et al. 2011). The absolute amplitude of the rogue waves solution corresponding

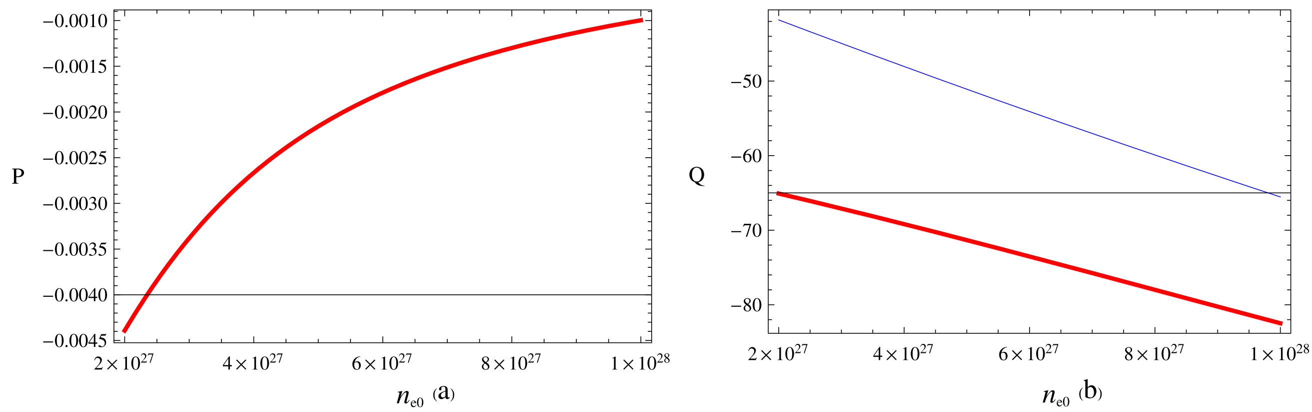

Fig. 1 The dispersion and nonlinearity coefficients of (given by Eqs. (9) and (10)) are shown against n_{e0} (cm^{-3}) for varying dust temperature $T_d = 0$ (*thin curve*) and $T_d = 900$ K (*solid curve*) at fixed wave number $k = 5$

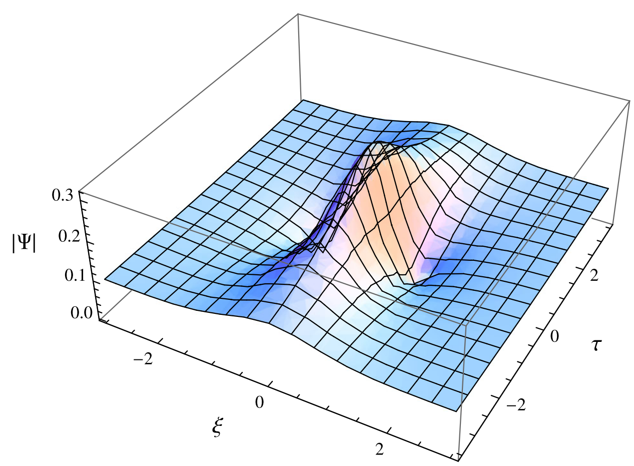

Fig. 2 The absolute of rational solution ($10^{-1} \times |\Psi|$) of NLSE, describing a rogue wave is plotted against space and time ($\times 10^2$) coordinates for $n_{e0} = 2 \times 10^{27}$ cm^{-3} and $n_{d0} = 1.9 \times 10^{23}$ cm^{-3} at $T_d = 900$ K

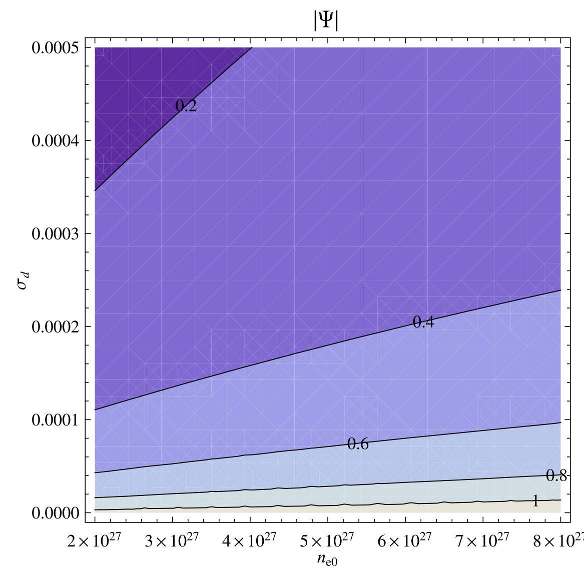

Fig. 3 The variation in absolute of rogue wave ($10^{-5} \times |\Psi|$) is plotted with respect to σ_d and n_{e0}

to Eq. (8) is depicted in the contour plot (Fig. 3). It is shown that the wave amplitude decreases with increasing the equilibrium electrons number density. However, the dust-to-ion Fermi temperature ratio (σ_d) also modify the wave amplitude in the given range. We have also reexamined the rogue waves solution at different times against the spatial coordinate (ζ) in Fig. 4. A decrease in amplitude of the rogue waves is observed. Thus our previous (Irfan et al. 2014) Figs. 8–11, have been slightly modified which were based on the KdV transformed NLS equation.

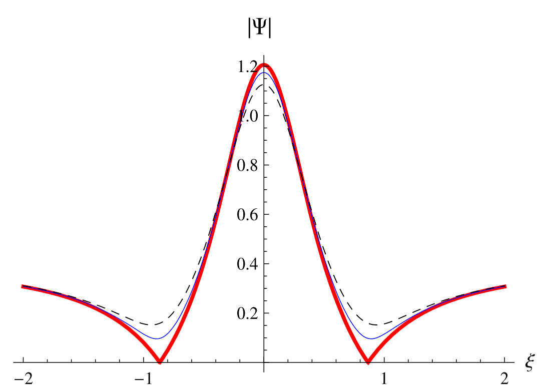

Fig. 4 The rogue wave ($10^{-2} \times |\Psi|$) is depicted at $\tau = 0$ (*solid curve*), $\tau = 30$ (*thin curve*) and $\tau = 50$ (*dashed curve*) with $n_{e0} = 2 \times 10^{27}$ cm^{-3} and $k = 10$

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