Response to "Comment on 'Nonlinear properties of small amplitude dust ion acoustic solitary waves'" [Phys. Plasmas 15, 104703 (2008)]

Cite as: Phys. Plasmas **15**, 104704 (2008); https://doi.org/10.1063/1.2991359
Submitted: 19 August 2008 . Accepted: 28 August 2008 . Published Online: 06 October 2008

M. R. Gupta, S. Sarkar, Manoranjan Khan, and Samiran Ghosh

Response to "Comment on 'Nonlinear properties of small amplitude dust ion acoustic solitary waves'" [Phys. Plasmas 15, 104703 (2008)]

M. R. Gupta,[1] S. Sarkar,[1] Manoranjan Khan,[1] and Samiran Ghosh[2]
[1]*Department of Instrumentation Science and Centre for Plasma Studies, Jadavpur University, Kolkata-700032, India*
[2]*Government College of Engineering and Textile Technology, 4, Cantonment Road, Berhampore, Murshidabad-742101, India*

(Received 19 August 2008; accepted 28 August 2008; published online 6 October 2008)

The objections are not justified. It should have been noted that ion charge number $z_i=1$ throughout the referred paper [Ghosh *et al.*, Phys. Plasmas **7**, 3594 (2000)]. There is no inconsistency in the formulation of the referred paper as explained in the text. © *2008 American Institute of Physics*.
[DOI: 10.1063/1.2991359]

We believe that the authors did not go through our paper[1] carefully (the ion charge number $z_i=1$ uniformly throughout the paper; even if one wishes to make a change, it is trivial). There is no inconsistency in the model of the referred paper.[1] In fact, expression 9(b) of our paper[1] is the standard expression[2–5] for the contribution to dust charging current from ion motion used in connection with the investigation of propagation of dust ion acoustic (DIA) waves based either on continuity and momentum equations or the Vlasov equation for ions (these two cases are equivalent).

To see this, note that the perturbed flow velocity as determined by the ion fluid equations is actually the velocity obtained by averaging over the random velocity of ions. As a result, these ions may be considered to be distributed about $\vec{V}_i$ as follows (temperature is in energy units):

$$\left(\frac{m_i}{2\pi T_i}\right)^{3/2} \exp\left[-\frac{m_i}{2T_i}(\vec{v}_i-\vec{V}_i)^2\right]. \quad (1)$$

Following Horanyi,[6] the ion induced orbital motion limited contribution to dust charging current is

$$\frac{J_{0i}}{2}\left[\left(\mathrm{M}^2+\frac{1}{2}-\chi_i\right)\frac{\sqrt{\pi}}{\mathrm{M}}\,\mathrm{erf}(\mathrm{M})+\exp(-\mathrm{M}^2)\right] = \pi a^2 e\sqrt{\frac{8T_i}{\pi m_i}}n_i\left[1-\frac{Q_d e}{4\pi\varepsilon_0 a T_i}+O\left(\frac{m_i|\vec{V}_i|^2}{2T_i}\right)\right], \quad (2)$$

where temperature is in energy units, Q_d is the dust charge, $4\pi\varepsilon_0 a$ is the capacitance of the spherical dust grain of radius a, and $\mathrm{M}(=|\vec{V}_i|/\sqrt{2T_i/m_i})$ is the relative Mach number. The other symbols are as according to Ref. 6. Clearly, neglect of $O(|\vec{V}_i|^2)$ terms leads to recovery of expression 9(b) of Ref. 1 in linear theory. In nonlinear theory, one might still expect a contribution from $O(|\vec{V}_i|^2)$ in dust charging dynamics, but for the scaling (for small amplitude wave) we have used, the expected contribution is absent.

Regarding their observation[7] about inclusion of dust dynamics, it is enough to remark that the principal purpose was the study of the effect of dust charging dynamics on the nonlinear DIA wave propagation. The dust fluid dynamics was introduced for the sake of a complete (joint) description of both DIA and dust acoustic (DA) modes, incorporating their interaction. The two roots λ_+ and λ_- of Eq. (32) of Ref. 1 correspond to the phase velocities of DIA and DA waves, inclusive of contributions representing their mutual interaction. The nonlinearity coefficient α and the dispersive coefficient β will correspond to the DIA or DA Korteweg–de Vries (KdV) soliton depending on which particular root is chosen. In the numerical results and the corresponding graphs we have restricted to the phase velocity of the DIA wave and hence the title of the paper. If the authors want, they can set $\lambda=\lambda_-$ and recover the corresponding properties for the DA KdV soliton (this is what is gained by including dust dynamics) and become convinced as, after all, the proof of the pudding is in the eating.

Finally, ion current to the dust grain is indeed different from what is given by Eq. 9(b) in Ref. 1 in astrophysical situations; e.g., when the ion distribution is nonthermal[8] or a sweep-up type distribution as in solar wind, where the ion flow velocity is much in excess of the ion thermal velocity. However, the paper under consideration is not addressed to such problems. Even if one introduces a constant zeroth-order ion velocity $\vec{V}_{i0}$ [e.g., in Refs. 2 or 9], it would merely introduce a minor change in the value of the dust charge $z(=z_d e^2/4\pi\varepsilon_0 a T_e)$. This is, however, of no consequence as it only introduces a small correction in the value of z in Figs. 2 and 3 of Ref. 1. Within the framework of the theoretical formulation of DIA (or DA) waves made until now, Eq. 9(b) in Ref. 1 is justified.

If the authors desire, they may proceed to a fully kinetic theoretical study of the motion of the plasma particles and dust grains including self-consistent dust charging and charging current.

[1]S. Ghosh, S. Sarkar, M. Khan, and M. R. Gupta, Phys. Plasmas **7**, 3594 (2000).
[2]R. K. Varma, P. K. Shukla, and V. Krishan, Phys. Rev. E **47**, 3612 (1993).

[3]M. R. Jana, A. Sen, and P. K. Kaw, Phys. Rev. E **48**, 3930 (1993).
[4]S. V. Vladimirov, K. N. Ostrikov, and M. Y. Yu, Phys. Rev. E **60**, 3257 (1999); **67**, 036406 (2003).
[5]D. Xiao, J. X. Ma, Y. Li, Y. Xia, and M. Y. Yu, Phys. Plasmas **13**, 052308 (2006).
[6]M. Horanyi, Annu. Rev. Astron. Astrophys. **34**, 383 (1996).
[7]S. S. Duha and A. A. Mamun, Phys. Plasmas **15**, 104703 (2008).
[8]S. Ghosh, R. Bharuthram, M. Khan, and M. R. Gupta, Phys. Plasmas **11**, 3602 (2004).
[9]S. Ghosh, M. Khan, and M. R. Gupta, Phys. Plasmas **13**, 102312 (2006).