Kaneko et al. Reply

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Kaneko *et al.* Reply: In [1] Sorasio *et al.* show that the experimental results obtained in our recent Letter [2] can be explained by using the theoretical model of Shukla *et al.* [3], which demonstrates that the wave is excited by the inverse electron Landau damping effect and by the parallel ion velocity gradient. However, it has already been shown in our Letter that the experimental data fit to a considerable extent into the theory containing these effects (see Fig. 5 in [2]) which is based on Eq. (A15) in the theory of Ganguli *et al.* [4], and it was explicitly stated that the experimentally obtained drift waves are driven by the inverse electron Landau damping effect.

Since the theory of Shukla *et al.* includes effects of a dust component, ion-neutral collisions, and unperturbed $E \times B$ drift, their treatment is useful for analyzing the weakly ionized dusty plasmas. In [1], however, these effects are neglected in order to analyze our experimental results in [2]. Furthermore, in the theory of Shukla *et al.* some essential physics necessary for clarifying our experimental results is absent as described below.

Equation (1) in [1] can be transformed for small $k_\perp \rho_s$, or $b \simeq 1$, as follows.

$$\begin{aligned}\gamma &= \left(\frac{\pi}{2}\right)^{1/2} \frac{\omega_{r\pm}^3}{(\omega_e^* \omega_{r\pm} + 2\omega_a^2 \sigma^2) k_z V_{te}} \times \left[\frac{\omega_e^*}{2} - k_z u_{i0} \mp A\right] \\ &= \left(\frac{\pi}{2}\right)^{1/2} \frac{\omega_{r\pm}^3}{[\omega_e^* \omega_{r\pm} + 2(\omega_{r\pm}^2 - \omega_e^* \omega_{r\pm})] k_z V_{te}} \times \left[\frac{\omega_e^*}{2} - k_z u_{i0} - \omega_{r\pm} + \frac{\omega_e^*}{2}\right] \\ &= \left(\frac{\pi}{2}\right)^{1/2} \frac{\omega_{r\pm}^3}{(2\omega_{r\pm} - \omega_e^*) k_z V_{ti}} \sqrt{\frac{\tau}{\mu}} \left(\frac{\omega_e^* + k_z v_d}{\omega_{r\pm}} - 1\right),\end{aligned} \tag{1}$$

where $\omega_{r\pm} = (\omega_e^*/2) \pm A$, $A \simeq \sqrt{(\omega_e^*/2)^2 + \omega_a^2 \sigma^2}$, v_d is the relative electron-ion drift in the ion frame, and the other notation is defined in [1,2]. Although this equation appears to be similar to Eq. (1) in our recent Letter [2], there is an important and intrinsic difference in discussing the effects of the Landau damping. The theory of Shukla *et al.* considers only the electron-wave resonant interaction (inverse electron Landau damping) and neglects the ion-wave resonant interaction (ion Landau damping). We agree with Sorasio *et al.* in the Comment that the ion Landau damping is insignificant for large $|\omega_{r\pm}/k_z V_{ti}|$ (typically >5), which corresponds to $\sigma^2 > 25$ in our experimental condition. In this large σ^2 regime, the theory of Shukla *et al.* becomes consistent with ours and is applicable to the experiment. For $\sigma^2 < 25$, however, the ion Landau damping has appreciable influence on the growth rate. The growth rate sharply decreases at $\sigma^2 \simeq 20$ as shown in Fig. 5 of [2], which can only be explained by increment of the ion Landau damping effect with a decrease in σ^2. On the other hand, because of the absence of the ion Landau damping term in Eq. (1) of [1], the theoretical growth rate described in Fig. 1 of [1] is very broad in the region of the smaller σ^2 and is positive even for $\sigma^2 < 10$ where the drift-wave instability in our experiment is entirely damped by the ion Landau damping. Thus, the instability growth is overestimated in the model of Shukla *et al.*

It is to be noted that we assume the direction of the relative electron-ion drift is positive in the ion frame in [2]. In this sense, the ω_{r-} solution in [1] and the ω_{r+} solution in [2] seem to have the same meaning and possibility of yielding the positive growth rate.

For $\Delta V_{ie} > 0$ in the notation in [2], namely, $\sigma^2 > 0$, A is larger than $\omega_e^*/2$, and, thus, the absolute value of the phase velocity of the wave in the ion frame $|\omega_{r\pm}/k| (= |[(\omega_e^*/2) \pm A]/k|)$ always increases with an increase in σ^2, which leads to the reduction of ion Landau damping and the destabilization of the wave by the inverse electron Landau damping.

Finally, we emphasize that the competition between the ion Landau damping and the inverse electron Landau damping is essential to the mechanism of destabilization and stabilization of the drift wave with increasing shear strength as described in our Letter.

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