Reply

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Bratenahl and Baum's comments are a published version of their questions as reviewers of our papers 1–4 (Stenzel and Gekelman [1981], Gekelman and Stenzel [1981], Gekelman et al. [1982a], and Stenzel et al. [1982a], respectively). We have earlier discussed these points with them at length but will repeat them again in this reply.

Following their lengthy introduction, the authors made three specific comments on our experiment:

1. Plate insulation increases the axial plasma current.
2. Ion current to the uninsulated plates exceeds the axial plasma current.
3. There is a net plate-directed electric field \( E_z \) inside the plasma.

Our response is as follows:

1. The induced plasma current is dependent upon the electron emission from the hot cathode, which is space charge limited due to the sheath criterion [Langmuir, 1929]. The plasma current has a negligible dependence on the plate insulation. We have verified this fact experimentally by operating with both insulated and bare plates. Thus Bratenahl and Baum's assumptions are not born out by our observations.

Their further assumptions that a conduction mode instability and 'IIFTE's a la 'DIPD' should occur is a mere speculation. The 'global nature' of these events is probably restricted to inverse pinch devices where, owing to lack of continued plasma supply the current terminates simply because of the plasma loss. As regards the conduction mode instability, the authors recently reversed their longstanding interpretation that anomalous resistivity is the cause of IIFTE's [Beeler, 1979]. They have not provided direct evidence that a double layer exists in the DIPD [Baum and Bratenahl, 1980]. Thus, with this poor understanding of the cause of IIFTE's in the DIPD the authors extrapolation to different experiments or the postulation of a 'global nature' has no basis.

2. We have measured the ion saturation current to several flat probes located at different points on the surface of the uninsulated plates. The total ion current to both plates calculated from these direct measurements does not exceed \( \sim 10\% \) of the measured axial plasma current. Thus, the authors' assumptions that \( I_{\text{ion}} > I_{\text{plasma}} \) does not agree with our observations. Their further speculation that the ion current to the plates is responsible for the plasma turbulence is also contradictory to our experience. Having run the experiment with both insulated and conducting plates, we find little difference worth reporting. The observed current disruptions and double layers in our experiment [Stenzel et al., 1982b] certainly do not depend on plate insulation.

Unrelated to the authors suggestions, we have been able to increase the net axial electric by reducing the plasma density. Similar to the slide-away regime in low density tokamaks [Piteroni and Segre, 1975] we then observe electron runaway.

Novel direct measurements of the distribution function \( f(v, r, t) \) have been performed [Gekelman et al., 1982b] and will be reported in detail. No macroscopic conduction mode instability has yet been found.

3. In our consideration, the transverse electric field is electrostatic and results from pressure gradients, \( E_z = (1/\eta e) \nabla (nkT) \). We agree with the authors that in paper 4, Figure 3b, the arrows are inadvertently reversed, i.e., the electric field should point away from the plates into the plasma where the pressure is largest. However, the resistivity and transverse dissipation \( E_z \cdot J_z \) were calculated with the correct sign, \( +1/\eta e \nabla (nkT) \). Thus, the authors conclusion that \( \eta \) and \( E \cdot J \) are incorrect is not valid.

A plate-directed electric field may exist in the sheath at the plate-plasma interface. The field is confined to some tens of Debye lengths (\( \lambda_D \approx 0.003 \) cm), which is negligible in comparison with the dimensions under consideration. Thus the plasma shields itself so that the surface electric field does not penetrate into the plasma interior.

The ion dynamics (see part 3, Figure 9) is the best evidence for our correct choice of the electric field. The unmagnetized ions following the net electric field drift away from the plates toward the plasma interior. If the field were plate directed, as the authors stipulate, the ions would have to drift toward the plates, which is not the case. Thus, their theoretical considerations from 'global boundary conditions' are contradictory to the observations.

In summary, while we appreciate the authors discovery of a sign error in Figure 3 of part 4, we found none of their three comments in agreement with our experimental evidence. They have focused their attention to the plate insulation, which is of minor importance in our experiment. Their claims of significant oversights and defects in our work are exaggerated and without basis. Finally, portraying their own work as 'the pioneering reconnection experiments' is unfair to the group at the Lebedev Physics Institute [Syrovatskii, 1981; Frank, 1976] whose independent, simultaneous (if not earlier) work on reconnection has contributed greatly to the field.

References


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