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Reply by Author to W. Schneider

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THE first two sentences in the abstract of the paper[1] by myself and E. Sogame† state quite clearly that our objectives were to contribute to an understanding of the new features introduced by radiative-fluid mechanical coupling in the low Reynolds number, blunt-body problem at hypersonic speeds and to illustrate how to circumvent the radiatively coupled shock layer and shock-transition zone. The last sentence of our paper[1] suggests that our considerations provide the framework for which further refinements of this problem could be carried out. W. Schneider apparently misunderstood the significance of the exposition of new fluid mechanical phenomena within very simple, understanding-enhancing situations as was done by myself and E. Sogame for this problem; he apparently has, a priori, also misunderstood the significance of the essential new fluid mechanical phenomena.

The low Reynolds number blunt-body problem at hypersonic speeds is characterized by a shock-transition zone whose thickness is comparable with the shock-layer thickness and viscous stresses and heat conduction are important in both layers, as elucidated by Cheng[2] for the radiationless thin-layer problem; fortunately, the shock-transition zone can be bridged by the modified Rankine-Hugoniot jump conditions thus enabling the independent solution of the shock layer possible, the shock-transition zone is subsequently solvable through using the now known properties of the outer edge of the shock layer as initial conditions. When radiative transfer effects become important they are important simultaneously in both the shock layer and the shock-transition zone. This observation can be arrived at even before solving the problem. In the vicinity of the (cold) wall and of the freestream, radiative emission is relatively unimportant compared with the relatively high-temperature region near the shock interface. For density-dependent emission, radiative emission is rendered even relatively less important in the outer region of the shock transition zone where $\bar{v} = 0(1)$ and $\bar{\rho} = 0(1)$.‡ However, near the shock interface $\bar{v} = 0(\epsilon)$ and $\bar{\rho} = 0(\epsilon^{-1})$, the local shock-transition zone density is of the same order as the shock layer density precisely in the region where the local radiative emission is important. The accumulated radiative heat loss through the shock-transition zone, with the dominant contribution coming from the vicinity of the shock interface, changes the shock-layer "boundary conditions" at the shock interface significantly as radiative transfer becomes significant. The radiative coupling of the two layers make their independent solution impossible. This radiative coupling is the new essence central to this problem and is borne out, of course, by our detailed but simple considerations.[1] These conclusions are entirely independent of the subsequent refinements of this problem.

W. Schneider makes the claim in the second to the last paragraph that the same problem of myself and Sogame[1] has been investigated by him with nonequilibrium effects included, to be reported in his forthcoming publications.§ But in his last paragraph, W. Schneider contradicts himself by admitting that radiative effects have indeed been ignored in his shock-transition zone. Thus the flowfield that Schneider considered does not, in fact, exist. However, he concludes, a posteriori, that his radiative transfer problem ought to be done (or ought to have been done!) within the fluid mechanical framework of our paper.[1] This suggestion, of course, was already implicit in the last sentence of our paper.[1]

Unfortunately, Dr. Schneider was not very well informed on the previous and recent developments that have occurred in the subject[1,3,4] related to his own work which he quoted in his Comments, as well as on the elucidation of some of the more interesting nonequilibrium processes in radiative gas dynamics that was done at Brown University.[5–9]

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‡ The notation follows that of Ref. 1.

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