Sprunt and Litster Reply: The Comment by Brand and Pleiner[1] (hereafter BP) points out that the free-energy expansion that we used to analyze the data in our Letter[2] (hereafter SL) is not the most general expansion allowed for the tilted hexatic system. The latter has the $\mathbf{q}$ space form $F_{\mathbf{q}} = a_{ijkl} q_i q_j \eta_k \eta_l$, where $\eta = (\theta, \phi)$. We shall now relate this result to Eq. (1) of SL. A primary consideration of our experiment was to probe a high-symmetry direction in the sample, so that the number of free parameters describing the scattering would be minimized. As stated in SL, we chose $q_\perp \equiv q_x$, $q_y \equiv 0$ for the in-plane wave-vector transfer, were $\hat{\mathbf{x}}$ lies along the aligned tilt direction. In this geometry, the surviving terms of $F_{\mathbf{q}}$ not included in Eq. (1) of SL are $q_x^2\theta\phi$, $q_z^2\theta\phi$, $q_xq_z\theta\phi$, $q_xq_z\theta^2$, and $q_xq_z\phi^2$.

We neglected the gradient coupling of θ and ϕ since (1) it is expected to be much less relevant[3] for the $S_C - S_I$ phase transition than the conjugate field coupling $H(\theta-\phi)^2$, which is included in Eq. (1) of SL and which x-ray measurements[4] show to be the truly crucial coupling; and (2) it changes the relative contribution of θ and ϕ to the normal modes of the system,[5] but does not affect the basic structure of the scattering from these modes. Of the terms involving the component of $\mathbf{q}$ perpendicular to the layers, we kept those in q_z^2 and neglected those in q_zq_x, since (1) the former were derived from the simplest model[6] of layer coupling in a stacked hexatic system; and (2) the former correspond to pure twist distortions of the liquid-crystal director and the bond-orientational directions, whereas the latter represent more complicated, coupled bend-twist distortions. Unfortunately, since our light-scattering geometry has $q_z^2 \ll q_\perp^2$, we cannot support the arguments for the form of the out-of-plane scattering with definitive experimental evidence. Instead, our present approach has been to choose a reasonable model which explains the data with the fewest and best determined parameters.

Turning to BP's criticism of Eq. (2) of SL, we agree that Eq. (1) of SL yields only two normal modes. Indeed, Eq. (2) of SL was derived by diagonalization of Eq. (1) and evaluation of the result at $q_z = 0$ and $q_z = \pi/t$ for the hydrodynamic mode, and $q_z = 0$ for the optical mode. [Equation (1) of BP is an evaluation of both modes at $q_z = \pi/t$.] Although our experimental geometry was designed only to accept fluctuations for $q_z \approx 0$, the finite sample thickness $(t - \lambda)$ means that discrete values of $q_z = n\pi/t$ $(n = 0, 1, \dots)$ can be scattered into the detector. A form-factor calculation shows that the scattered intensity is proportional to $\sin^2(n\pi/2)/(n\pi/2)^2$; thus only $n = 0,1$ should be expected to contribute significantly. In analyzing our data, we were unable to detect the $n = 1$ contribution to the optical mode. Analysis of the S_C phase dynamics, however, convinced us that the $n = 1$ component from the hydrodynamic mode needed to be included. Subsequent measurements (unpublished) on very thin films $(t \ll \lambda)$, where $n = 1$ dynamics should be unobservable, confirm this. We intend to study finite-thickness effects further by utilizing an experimental geometry which directly probes the out-of-plane scattering in thick films.

We should like to add that Eq. (2) of SL does *not* contain an optical prefactor which arises from the finite tilt of the liquid-crystal molecules with respect to the layer normal, and which, on the basis of recent and more extensive data, we now believe to be important for our range of q^2. Inclusion of this factor does not, however, change the main results of SL. Details will appear in a longer paper.

To summarize, we believe that Eq. (1) of SL is a reasonable model for the free energy of the fluctuations in a tilted hexatic which have their in-plane component along the direction of an aligned tilt field. Additional terms do not enhance the description of our data but do result in poorly determined, highly correlated parameters. Moreover, Eq. (2) of SL contains the physics of two normal modes; a higher-order, twist-scattering contribution to the hydrodynamic fluctuations appears as a separate term because of the discreteness of q_z imposed by the finite sample thickness.

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[1]Helmut R. Brand and Harald Pleiner, preceding Comment [Phys. Rev. Lett. **61**, 1257 (1988)].

[2]S. Sprunt and J. D. Litster, Phys. Rev. Lett. **59**, 2682 (1987).

[3]Robijn Bruinsma and D. R. Nelson, Phys. Rev. B **23**, 402 (1981).

[4]J. D. Brock, A. Aharony, R. J. Birgeneau, K. W. Evans-Lutterodt, J. D. Litster, P. M. Horn, G. B. Stephenson, and A. R. Tajbakhsh, Phys. Rev. Lett. **57**, 98 (1986).

[5]D. R. Nelson and B. I. Halperin, Phys. Rev. B **21**, 5312 (1980).

[6]C. Deutsch and S. Doniach, Phys. Rev. B **29**, 2724 (1984).