Electronic Supplementary Information for Relaxation dynamics in a binary hard-ellipse liquid

Wen-Sheng Xu*

James Franck Institute, The University of Chicago, Chicago, Illinois 60637, USA

Zhao-Yan Sun† and Li-Jia An‡

State Key Laboratory of Polymer Physics and Chemistry,

Changchun Institute of Applied Chemistry, Chinese Academy of Sciences,

Changchun 130022, People's Republic of China

* wsxu0312@gmail.com

† zysun@ciac.ac.cn

‡ ljan@ciac.ac.cn

S1. STATIC STRUCTURE OF THE BINARY HARD ELLIPSES

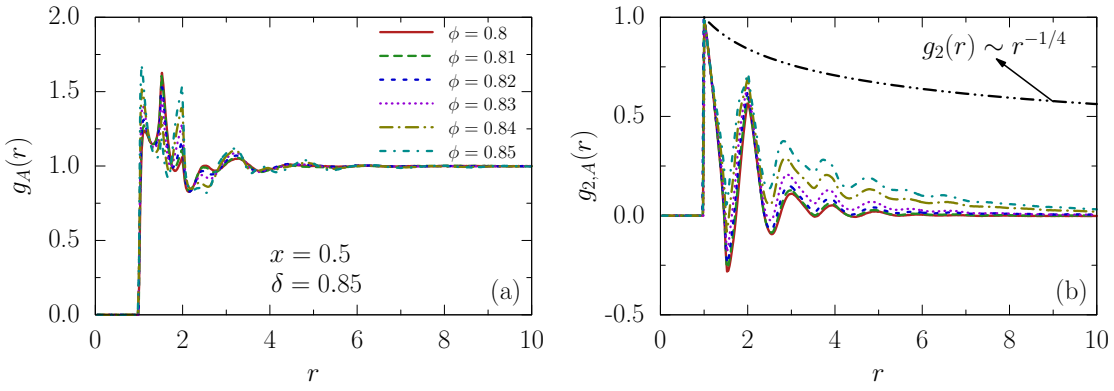

FIG. S1. (a) Pair correlation function $g_A(r)$ and (b) angular correlation function $g_{2,A}(r)$ for the large particles at various area fractions ϕ [indicated in (a)] in the binary hard ellipses with the size ratio $\delta = 0.85$ and the number concentration of the small particles $x = 0.5$. The black line in (b) highlights the fact that $g_{2,A}(r)$ for the binary mixture decays much faster than the power law $g_2(r) \sim r^{-1/4}$, indicating the absence of any long-range orientational order in the system.

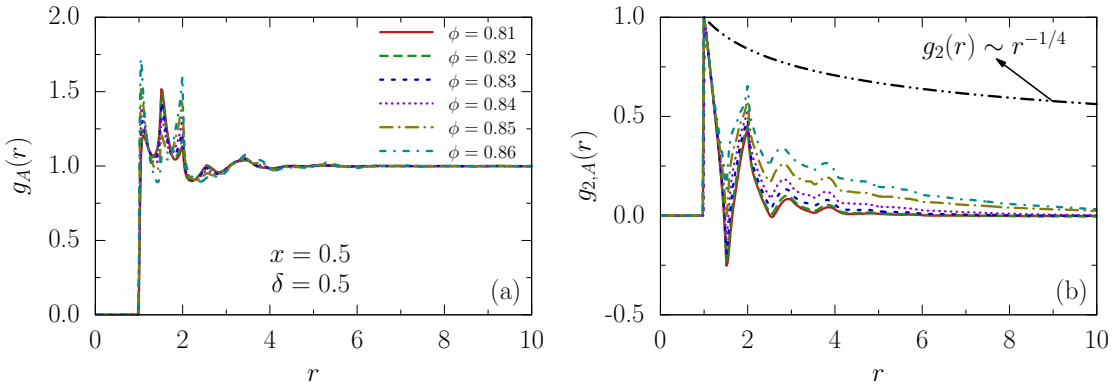

FIG. S2. (a) Pair correlation function $g_A(r)$ and (b) angular correlation function $g_{2,A}(r)$ for the large particles at various area fractions ϕ [indicated in (a)] in the binary hard ellipses with the size ratio $\delta = 0.5$ and the number concentration of the small particles $x = 0.5$. The black line in (b) highlights the fact that $g_{2,A}(r)$ for the binary mixture decays much faster than the power law $g_2(r) \sim r^{-1/4}$, indicating the absence of any long-range orientational order in the system.

This section provides additional evidence that the binary hard-ellipse mixtures investigated in the present work exhibit neither long-range positional nor orientational order upon

increasing density. Figures S1 and S2 display the pair correlation functions $g_A(r)$ and the angular correlation functions $g_{2,A}(r)$ for the large particles at various area fractions ϕ for $\delta = 0.85$ and $\delta = 0.5$, respectively, when the number concentration of the small particles is fixed at $x = 0.5$. Definitions for pair correlation function and angular correlation function can be found in Ref. [1]. As shown in Figs. S1(a) and S2(a), the pair correlation function $g_A(r)$ quickly decays to unity and only displays several peaks at short distances, indicative of the absence of long-range positional order. In addition, Figures S1(b) and S2(b) imply that the angular correlation function $g_{2,A}(r)$ decays much faster than that in a nematic liquid crystal, where the angular correlation function decays slower than the power law $g_2(r) \sim r^{-1/4}$ [1]. Thus, the binary mixtures also remain disordered in the rotational degrees of freedom. Therefore, Figures S1 and S2 further confirm that the long-range order in the binary hard ellipses investigated in the present work is suppressed in both the translational and the rotational degrees of freedom.

S2. TIME-DENSITY SUPERPOSITION PROPERTY OF TIME CORRELATION FUNCTIONS IN THE BINARY HARD ELLIPSES

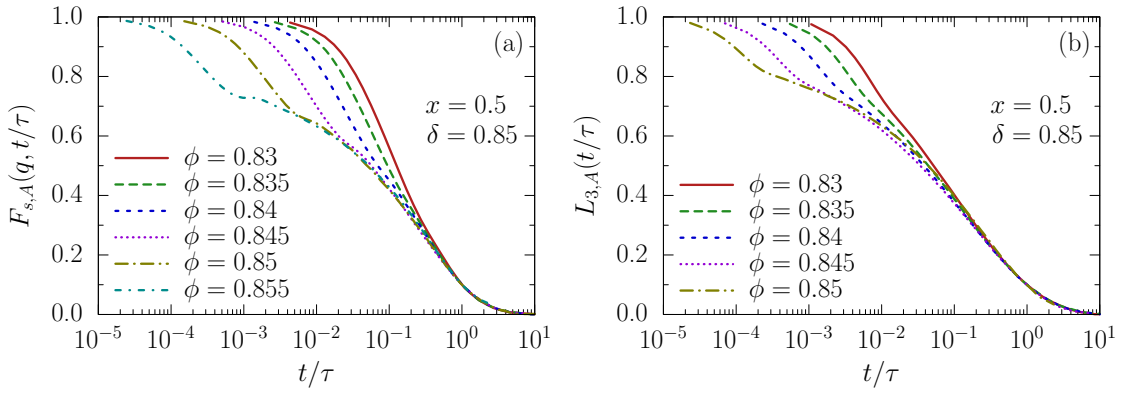

FIG. S3. (a) Self-intermediate scattering function $F_{s,A}(q, t/\tau)$ at $q \simeq 4.0$ and (b) 3rd order orientational correlation function $L_{3,A}(t/\tau)$ for the large particles as a function of t/τ with τ being the corresponding relaxation time at various area fractions ϕ in the binary hard ellipses with the size ratio $\delta = 0.85$ and the number concentration of the small particles $x = 0.5$. Data collapse at long times indicates that time correlation functions satisfy the t-ϕ superposition property in the binary hard ellipses in both the translational and the rotational degrees of freedom.

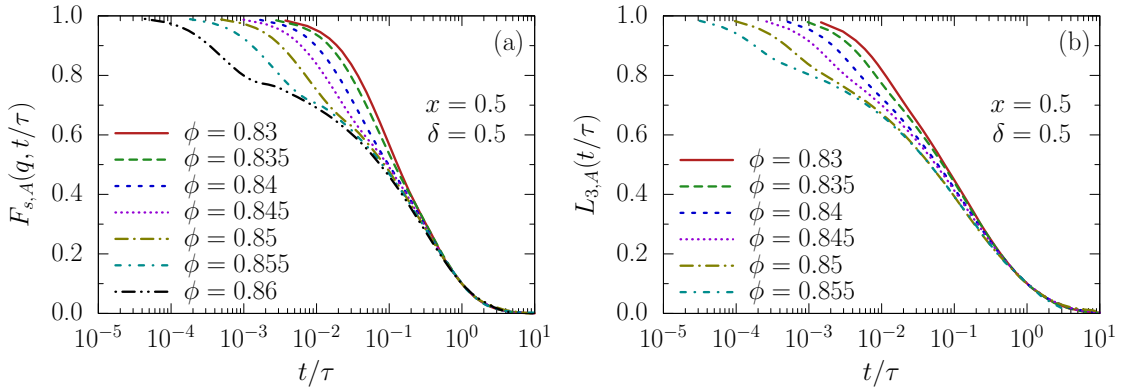

FIG. S4. (a) Self-intermediate scattering function $F_{s,A}(q, t/\tau)$ at $q \simeq 4.0$ and (b) 3rd order orientational correlation function $L_{3,A}(t/\tau)$ for the large particles as a function of t/τ with τ being the corresponding relaxation time at various area fractions ϕ in the binary hard ellipses with the size ratio $\delta = 0.5$ and the number concentration of the small particles $x = 0.5$. Data collapse at long times indicates that time correlation functions satisfy the t-ϕ superposition property in the binary hard ellipses in both the translational and the rotational degrees of freedom.

This section provides additional results for illustrating the characteristic glassy dynamics in the binary hard ellipses investigated in the present work. Specifically, Figures S3 and S4 display the self-intermediate scattering function $F_{s,A}(q, t/\tau)$ at $q \simeq 4.0$ and the 3rd order orientational correlation function $L_{3,A}(t/\tau)$ for the large particles as a function of t/τ for $\delta = 0.85$ and $\delta = 0.5$, respectively. Here, τ is the relaxation time, defined as the time where the corresponding time correlation function decays to 0.1. Data collapse is observed at long times for both size ratios and for both $F_{s,A}(q, t/\tau)$ and $L_{3,A}(t/\tau)$, implying that the t-ϕ superposition property is satisfied in both the translational and the rotational degrees of freedom. This superposition property is also a signature of the glassy dynamics, as predicted by the mode-coupling theory [2] and observed in other glass-forming liquids (see, e.g., Ref. [3]), thereby providing additional evidence for the appearance of characteristic glassy dynamics in the binary hard ellipses in both the translational and the rotational degrees of freedom. We note that the t-ϕ superposition property in the binary hard ellipses appears only at sufficiently high densities (i.e., ϕ is larger than ~ 0.83 for the binary mixtures investigated), which are typically above the onset density where the time correlation function

begins to develop a two-step decay.

---

[1] W.-S. Xu, Y.-W. Li, Z.-Y. Sun, and L.-J. An, J. Chem. Phys. **139**, 024501 (2013).

[2] W. Götze, *Complex Dynamics of Glass-Forming Liquids: A Mode-Coupling Theory*, 1st ed. (Oxford University Press, Oxford, 2008).

[3] G. Foffi, W. Götze, F. Sciortino, P. Tartaglia, and T. Voigtmann, Phys. Rev. E **69**, 011505 (2004).