Supplementary information.

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Arrangement of the "narrow" patchy particles ($l = 0.34\sigma$) of each kind in the first bilayer and corresponding density profiles are shown in Figures 1 2 for two distinct replicas. For the first case (Figure 1), one can see two domains of particles A and B in a single layer of the bilayer. Those domains have triangular symmetry, and the distance between particles of the same kind is $r \approx 1.56$, indicating that the domains are not densely packed. For the second replica (Figure 2), the same symmetry was observed in the each of the layers of the bilayer. However, the same structure is formed by a single component.

In the systems with the "wide" patches ($l = 0.40\sigma$) that are subjected to a weak external field, we observe that the bilayer's structure is essentially the same as in the case of the narrow patches (Figure 3). The only difference is the increased distance between the particles of the same kind which is $r \approx 1.65$. Figure

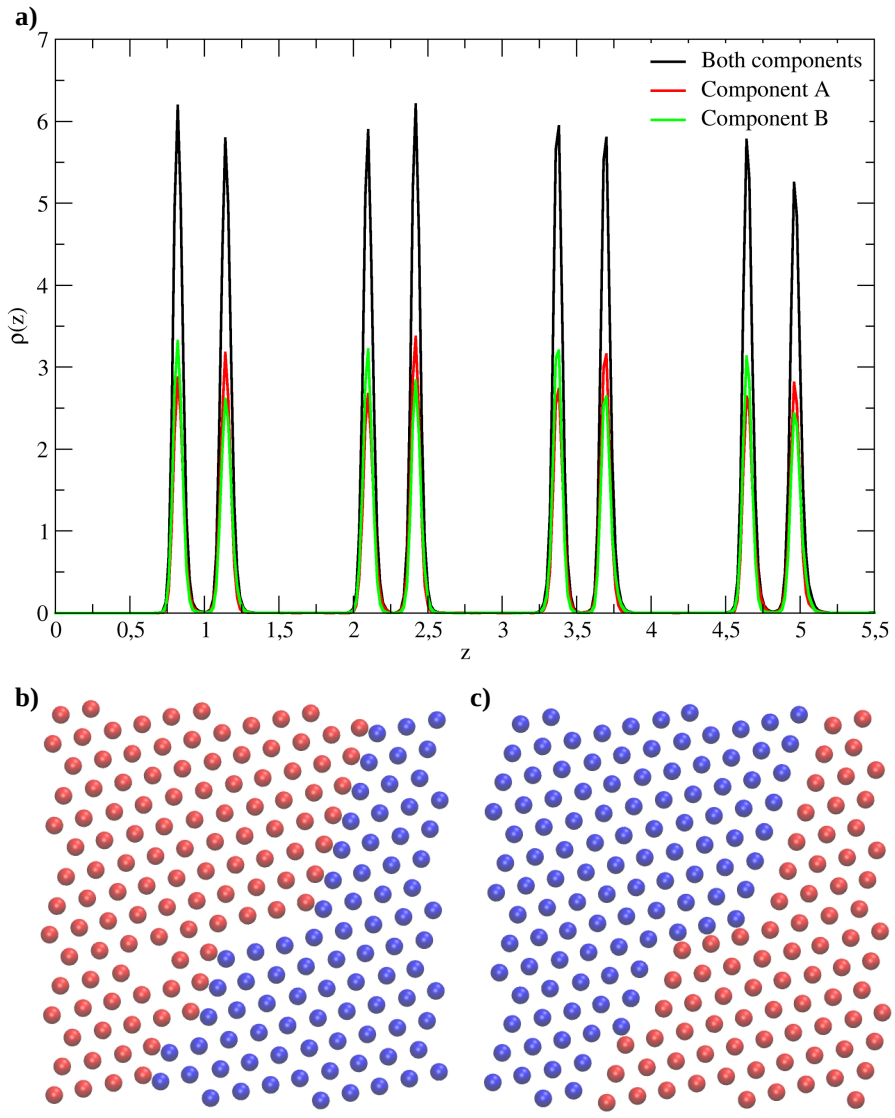

Figure 1: Part (a): total density profiles and for each of the components. Parts (b-c): snapshots of each of the layers forming the bilayer at distances $0.5 < z < 1.0$ and $1.0 < z < 1.5$, respectively. Patchy particles of different species are in different colors.

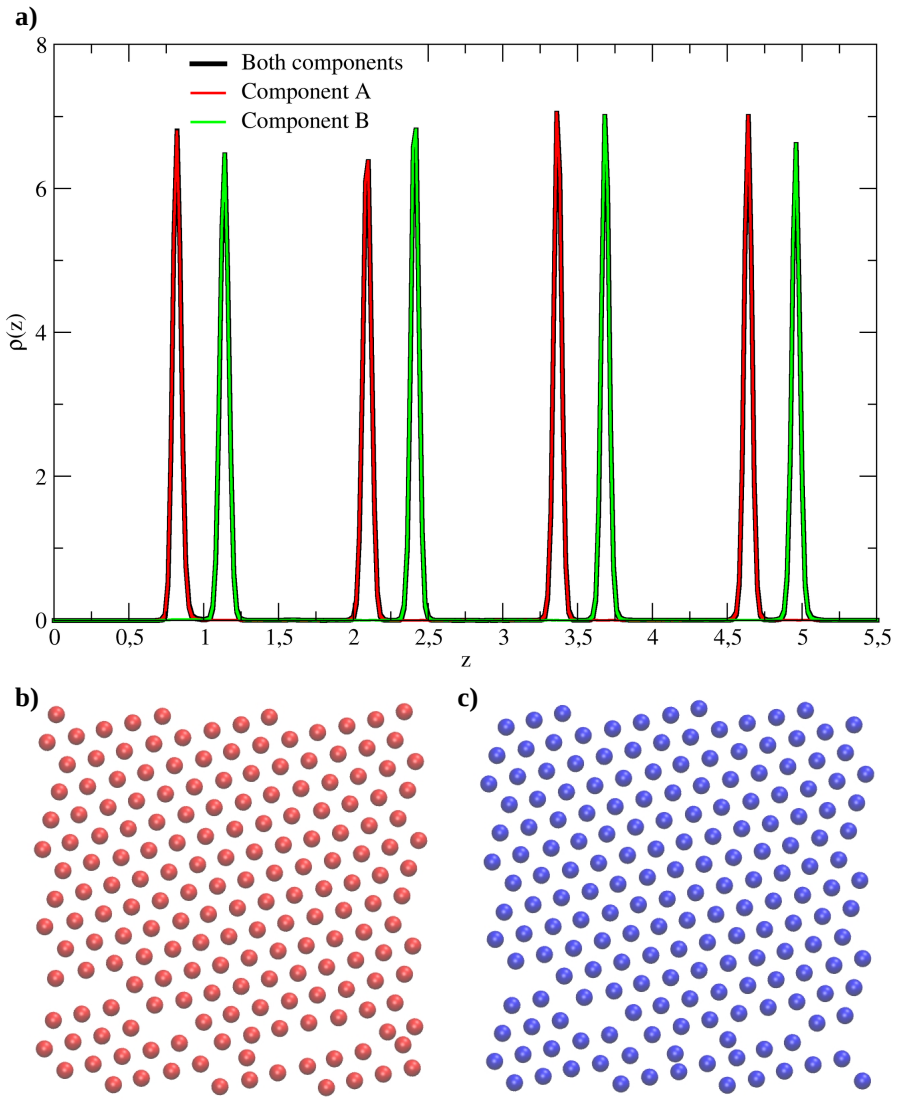

Figure 2: Part (a): total density profiles and for each of the components. Parts (b-c): snapshots of each of the layers forming the bilayer at distances $0.5 < z < 1.0$ and $1.0 < z < 1.5$, respectively. Patchy particles of different species are in different colors.

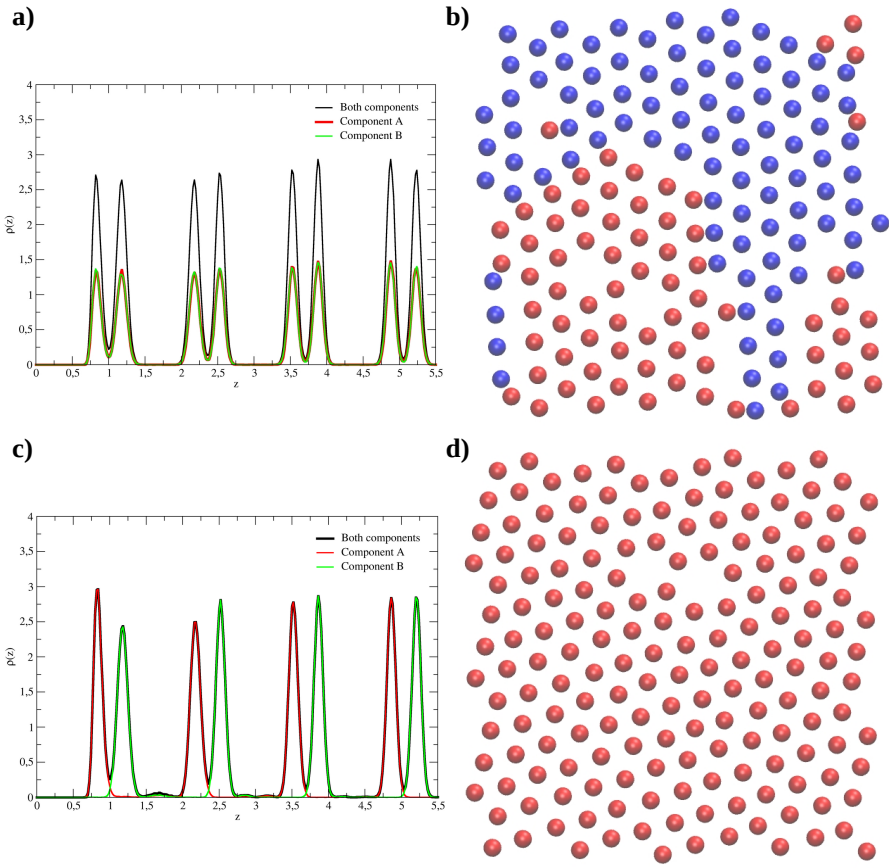

Figure 3: Parts (a) and (c): total density profiles and for each of the components. Parts (b) and (d): snapshots of a single layer of the bilayer at distances $0.5 < z < 1.0$ for two distinct replicas. Patchy particles of different species are in different colors.