Supplementary Material

S1. Correlation between String Formation and Energy Jumps

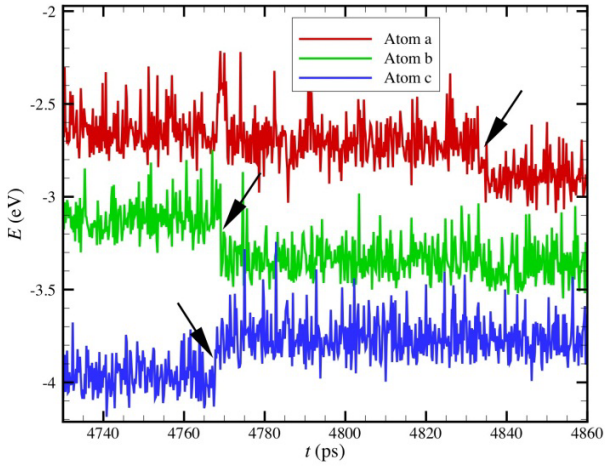

Figure S1. Potential energy as a function of simulation time (≈ string lifetime t^*) for three atoms who exhibit cooperative motions within this time window. For the sake of clarity, energy of each atom has been shifted by a constant value.

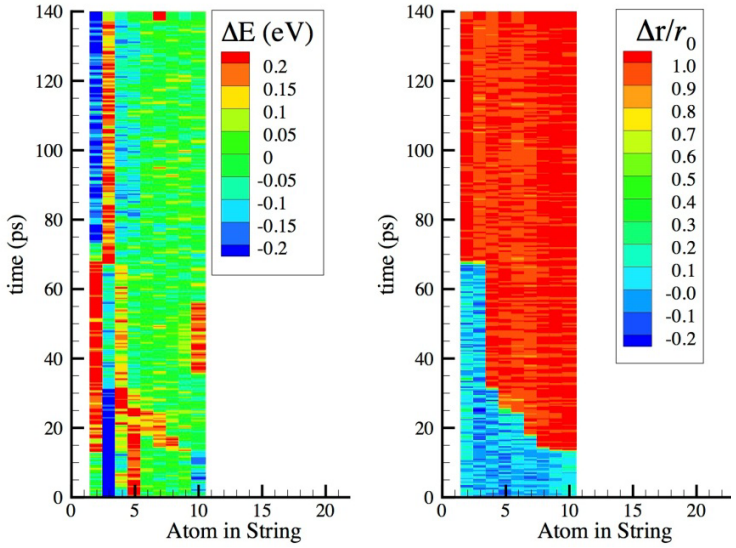

Figure S2. Potential energy fluctuations of atoms involved in collective string-like motion (atom 2) within the NP interfacial region over the timescale longer than the lifetime of the strings t^* = 130 ps where N = 2899 at T = 1000 K. Potential energy and displacement of type 2 atoms at T = 1000 K where the y-axis denotes time in units of the caging time at which $\langle u^2 \rangle$ is defined. The y-axis extends to the string lifetime, t^*. Note that particle displacement along the string by a series of jumps in $E(t)$. The number of string particles involved in large energy is apparently smaller at low T.

S3. Velocity Autocorrelation Function

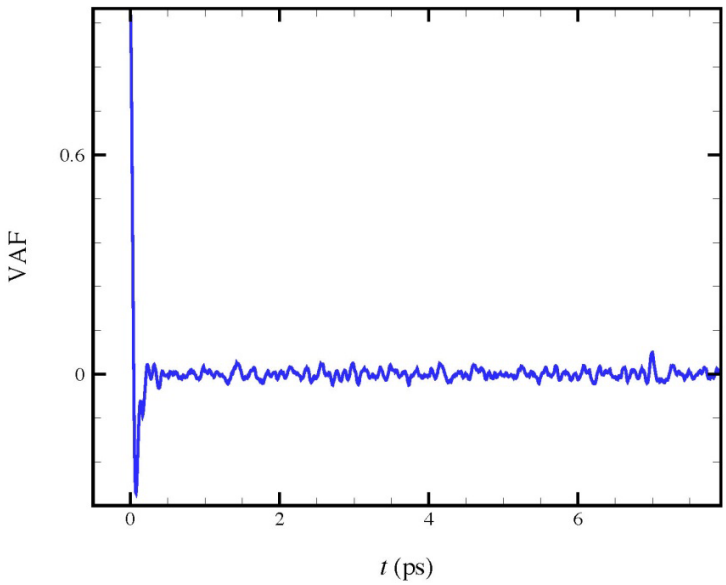

Figure S3. The velocity autocorrelation function of $N = 369$ NP at $T = 1000$K.

The velocity autocorrelation function, $\mathrm{VAF}(t) \equiv \langle \mathrm{v}(t)\mathrm{v}(0)\rangle / \langle \mathrm{v}(0)^2\rangle$, for the interfacial region of N=369 NP at T = 1000K is shown in Fig. S3. We see that long time power-law tail is not apparent in our VAF(t) for the interfacial atomic dynamics of our NP. Instead, the long-time dynamics is conspicuously rather oscillatory and noisy. In particularly, the pre-melted fluid state is more suggestive of a disordered solid or hexatically-ordered fluid than a simple liquid.