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Binary Colloidal Superlattices Assembled by Magnetic Fields[1]

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Colloidal particle superlattices represent a fascinating class of complex materials which in many cases have corollary structures at the atomic scale. These complex systems thus not only help elucidate the principles of materials assembly in nature, but further provide design criteria for fabrication of novel materials at the macroscopic scale. Methods for assembling colloidal particle superlattices include controlled drying, ionic interactions, and dipolar interactions. However, a general pathway for producing a wider variety of colloidal crystals remains a fundamental challenge. Here we demonstrate a versatile colloidal assembly system in which the design rules can be tuned to yield over 20 different pre-programmed lattice structures, including kagome, honeycomb, square tiles, as well as a variety of chain and ring configurations. We tune the crystal type by controlling the relative concentrations and interaction strengths between spherical superparamagnetic and diamagnetic particles. An external magnetic field causes like particles to repel and unlike particles to attract. The combination of our experimental observations with potential energy calculations of various lattice structures suggest that the lowest energy lattice configuration is determined by two parameters, namely the dipole moment and relative concentration of each particle type.

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