Topologically protected colloidal calligraphy

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Not only for children learning how to write can be a challenge of obtaining independent control over multiple degrees of freedom – even though, once met, it helps to produce beautiful outcomes, ranging from the first self-written greeting card to calligraphic masterpieces. The same applies to scientists that try to elicit their working system a charming effect. Having this in mind, I will present experiments where I use independent control over the four degrees of freedom of paramagnetic colloidal rods on a substrate to let them write arbitrary words in a pen-like manner. The rods are assembled from spherical paramagnetic colloidal particles which are subject to a time-periodic external magnetic field and are placed on top of a substrate with space-periodic magnetization. I will theoretically explain how the independent control is achieved by decoupling magnetic dipolar particle–particle and particle–substrate interactions, making use of the first and second moment of the external magnetic field. Furthermore the topological aspects of this system, necessary in order to assess the experimental robustness of the colloidal calligraphy, will be presented and I will give a preview on future extensions of this system to more degrees of freedom.