Packing of Elastic Wires in Three-Dimensional Cavities

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A finite element program is developed to simulate the packing and coiling of elastic wires in three-dimensional cavities. The wire is modelled with third order beam theory and embedded into a corotational formulation to capture the geometric nonlinearity resulting from large rotations and deformations. Wire-wire contacts are found efficiently with the aid of linked cell lists. The hyperbolic equations of motion are integrated in time using two different integration methods from the Newmark family: Implicitly with a Newton-Raphson iterative solver combined with a line search algorithm, and explicitly with an adaptive-timestep predictor-corrector scheme. The two methods reveal fundamentally different suitability for the problem of strongly self-interacting finite elements as they are encountered in densely packed cavities, in particular, the implicit scheme is unable to access the dense regime due to convergence failure at multiple self-contacts. The computational performance of the two methods is compared, and their parallelization is discussed. With the explicit solver, some aspects of the packing of frictionless elastic wires with zero intrinsic curvature in hard ellipsoidal cavities are studied as a first step toward arbitrary or deformable cavities, i.e.~away from the spherical symmetry investigated in recent studies.