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A vibrating sitar string: Modeling the 3D dynamics of a plucked string impacting a spatial obstacle with friction

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In some musical instruments of Indian origin, such as sitar, veena, or tambura, the string termination is a shallow curved (parabolic) bridge. The string is usually plucked obliquely and interacts with the bridge, thus producing a buzzing or ringing tone which is significantly different from stringed instruments with knife edge supports like guitar. The string is also not restricted to planar motion and friction between bridge and string plays an important role in damping the non-planar motion. A mathematical model is presented for simulating a 3D vibrating string as it impacts a curved obstacle with friction. The bridge is represented as a foundation model with nonlinear visco-elastic springs; multiple distributed spatial impacts occur between the bridge and string, however the locations of these are not known in advance so must be determined during the simulation. Galerkin approximation is used to reduce the partial differential equations of motion to a set of nonlinear ordinary differential equations. These equations have been solved numerically for different contact and friction conditions. Parametric studies show the effect of bridge geometry, impact damping, and friction on the bidirectional vibration behavior of the string subject to an oblique plucking idealized as an initial condition.