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Dynamics of the TAMA 2D X-pendulum vibration isolation system

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A two-dimensional X-pendulum system has been developed to provide low-frequency vibration isolation in the TAMA 300 m laser interferometric gravitational wave detector. As a result of experience with the first prototype, the second incorporates improved, tool-steel clamps for reduced damping, and a high precision adjustment mechanism for finer tuning. Instead of pulling the X-wire through the clamp to tune the system, each X-wire clamp is mounted at the end of a lever and moved bodily by a double screw actuator, which eliminates the perturbation from tightening the clamps after the tuning. As well as the pendulum modes of the system, which have a very low frequency and contribute vibration isolation, there will be inevitably be a number of elastic resonances, some of which may be in the signal band of the interferometer. We present a complete normal mode analysis of the X-pendulum, including the full mode spectrum, the Q factors of the modes and the expected thermal noise. We compare the frequency and Q values with experimental results.