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Lightsaber: A simulator of the angular sensing and control system in LIGO

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The fundamental requirement for the angular sensing and control (ASC) scheme is to suppress the angular mirror motion at low frequencies, to overcome radiation pressure induced angular instabilities, without reintroducing noise in the GW signal. In the process of controlling test masses' angular motion at low frequencies, high-frequency noise is introduced in the observation band originating mainly from the readout noise of sensors. During the 03 run, controls noise dominated the noise budget approximately between 10 Hz and 25 Hz, and it was a significant noise source up to 55 Hz and there is no straightforward solution. We need better tools to analyze the system and for the development of solutions. We present Lightsaber, a new time-domain simulator of the ASC in LIGO. The simulation is a full, nonlinear simulation of the optomechanical system consisting of the high-power cavity laser beam and the last two stages of suspension in LIGO with the control system, focusing on pitch dynamics. Main noise inputs are power fluctuations, read-out noise of sensors, seismic noise from the ISI, and suspension damping noise. There is the conversion between the local and global basis of the angular motion in the linear feedback control, exactly as in the real system. Some of the studies that can be done with this simulation are understanding the role of DC miscentering and laser power fluctuations for angular dynamics and nonlinear angular mirror pitch motion to strain noise coupling.

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