Hearts on Fire

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The left ventricle is the heart's powerhouse, responsible for pumping oxygen- and nutrient-rich blood to each and every tissue throughout the body. By consequence, diseases affecting this laborious chamber are not only more common but often more serious. The fluid dynamics in the healthy left ventricle is characterized by the impulsive formation of a vortex ring during its filling phase which facilitates the following ejection with very little energy loss. In the case of a leaking aortic valve however, the left ventricle will fill from two sides, resulting in the interaction between two pulsatile jets in a confined elastic vessel, marking a new and unique fluid dynamics problem. Here, we show the backward finite-time Lyapunov exponent in the healthy and diseased left ventricles, revealing the attracting Lagrangian coherent structures associated with the aortic (A) and mitral (M) inflows. The background shows the time-frequency spectra of velocity signals over one cardiac cycle taken at the entrance of the mitral (right) and aortic (left) inflows for the healthy (top) and diseased (bottom) cases. The overlay and perceptually-uniform colormap (thanks to Stéfan van der Walt and Nathaniel Smith) are such that the high frequency bursts (up to 200 Hz) occurring early in the filling phase give the appearance of fire.