Exposing chaos in a falling disk's flutter - four types of behaviors discovered that characterize disks falling in liquid - Brief Article

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The trick is to drop a playing card into a hat resting at your feet. If the card is held vertically when released, it flutters wildly and completely misses the target. Held horizontally, it settles gently, with little wayward motion, directly into the hat.

This phenomenon, sometimes displayed with coins dropped in liquids instead of cards in air, is not only the subject of amusements and bets, but also a topic of considerable interest to researchers studying chaotic dynamics. It has applications in chemical engineering, meteorology, sedimentology, and other fields.

Performing experiments on disks failing in liquids, researchers have now identified four distinctive types of behavior, which depend on such factors as the disk's diameter and density and the liquid's viscosity. The physicists also obtained the first experimental evidence of an unusual type of transition from periodic to chaotic motion that had been predicted but not observed.

Stuart B. Field of Colorado State University in Fort Collins, Franco Nori of the University of Michigan in Ann Arbor, and their coworkers report the results in the July 17 Nature.

The work of Field and his colleagues follows up on a number of recent theoretical studies modeling the tumbling and drifting motion of a falling leaf, sheet of paper, or stiff card (SN: 9/17/94, p. 183). These efforts suggested that, under certain circumstances, the motion of failing bodies may be chaotic.

In the new experiments, steel and lead disks, ranging in diameter from 5.1 to 18.0 millimeters and in thickness from 0.076 to 1.63 mm, were dropped in water and mixtures of glycerol and water.

In a highly viscous liquid, a disk dropped with any orientation quickly settles into and maintains a horizontal position as it falls. At lower liquid viscosities, large-diameter disks oscillate with a well-defined period. A disk of

smaller diameter and low density displays chaotic motion, swinging back and forth more and more widely until it flips over, tumbles, then returns to an oscillating mode. Disks of small diameter and high density tumble, continually turning end over end while drifting to one side.