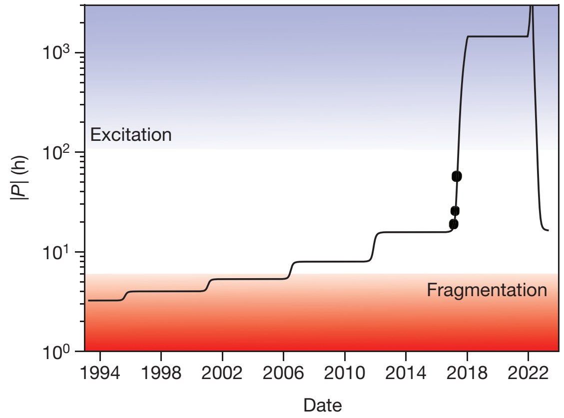

Figure 4 | Extrapolation of the rotation period of comet 41P in time. We modelled past and future absolute values of the period ($|P|$) by extrapolating the 2017 torques to other perihelion passages (upward steps). This scenario suggests that the nucleus could evolve from rapid rotation near the fragmentation limit[3] (red shading) to an excited, unstable spin state[4,5] (blue shading) in only a few orbits. The 2017 observations are indicated by filled circles.

indicate that most comets go through a large change in their rotation period soon after their activation[5]. This large change leads to a temporary excitation of the spin state of the nucleus, and for most comets the rotation period will evolve slowly thereafter. Simulations also show that, in some cases, uniformly active surfaces can cause comets to respond unpredictably to changes in their spin state. Such comets may have inherently variable spin states, experiencing large changes in their rotation period during each perihelion passage.

Projecting back in time, comet 41P may have been near the critical fragmentation limit (with a period of around 5 h)[3] in the recent past. It exhibited large outbursts in activity in 1973 and 2001[15,22], and these events may be related to the evolution of its spin state. The rapid rotation may have caused these outbursts via fragmentation or landslides[23]; alternatively, the outbursts may have given rise to the spin evolution by exposing new active areas that generate outgassing torques.

Online Content Methods, along with any additional Extended Data display items and Source Data, are available in the online version of the paper; references unique to these sections appear only in the online paper.

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