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# 147P/Kushida-Muramatsu and temporary satellite capture

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## Abstract

Comet 147P/Kushida-Muramatsu, discovered in 1993, is shown by a numerical integration study to have been captured as a jovian satellite from 1949 to 1961. Completing two full revolutions around Jupiter and with a capture duration of 12 yr, it is ranked 3rd among known comets in both these respects. Coming through the region near the $L_2$ libration point from the Centaur region beyond the jovian orbit, it escaped via $L_1$ to the quasi-Hilda comet region, demonstrating the role of the latter region as a dynamical route to and from jovian temporary satellite capture, via the Hill's sphere.

## Temporary Satellite Captures and Orbiters

Only a few discovered comets have been known to be temporarily captured as satellites by Jupiter. Some, such as 39P/Oterma in 1936–38 [1], involve the comet flying through the region near Jupiter in a rather short time. In other cases, termed orbiters [2], at least one full revolution about Jupiter is completed and the capture phase may last about a decade or more. The known examples are 82P/Gehrels 3 [3], 111P/Helin-Roman-Crockett [4], P/1996 R2 Lagerkvist [5], and most famously D/1993 F2 Shoemaker-Levy 9. Numerical integrations [6] suggested that the capture duration of D/1993 F2 lasted more than 50 yr which would be the longest of all these comets.

## Quasi-Hilda Comets and Kushida-Muramatsu

Temporary satellite capture can be an intermediate state in the transfer of comets from outside to inside Jupiter's orbit, inside to outside, or inside and back to inside [7]. Moreover, the inside region often corresponds dynamically to the Hilda asteroid zone. All the above orbiter examples are quasi-Hilda comets (QHCs), although this is just known statistically for D/1993 F2 since it was already orbiting Jupiter at the time of discovery and there are large uncertainties in tracing its exact orbital history.

We verified the orbiter events of 82P, 111P and 1996 R2, and then integrated all the other objects in the QHC list [8] back 100 yr, a timescale over which the computed orbital evolution has a reasonable chance of being real. It is found [9] that Comet 147P/Kushida-Muramatsu, discovered in 1993, orbited Jupiter as a satellite from 1949–61. The result is confirmed by integrating more than 200 orbital clones of 147P whose initial elements are [10] also consistent with observations.

## Implications

This confirms the importance of long ($\gtrsim$10 yr) jovian satellite capture as a route, via the $L_2$ (outer) and $L_1$ (inner) Lagrangian points, from the Centaur region to the QHC zone. Examples are 82P, 1996 R2 and now 147P. The QHC region is also a *source* for temporary satellite capture, as shown by 111P and (probably) 1993 F2.

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