

Video Animation of an Orbital Streamline in the Disk of a Galaxy

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29 Dec 2014

Searching the internet for an animation which illustrates the concept of an orbital “streamline” in the disk of a galaxy produced surprisingly few results. Therefore I produced this animation which I hope provides a clear visual explanation.

This paper presents a short video animation, which illustrates a streamline of orbits in a galactic disk. A precessing elliptical streamline is modelled in a simple power-law gravity field in which attraction towards the galactic centre is proportional to the inverse of the distance from the galactic centre (this field is sometimes called the flat velocity field, or the simple logarithmic potential).

The video is at vimeo.com/115869688

All orbits in this field have significant apsidal precession. Therefore each individual orbit is un-closed and traces a rosette-shaped path. The numerous orbits however may be co-ordinated to form a precessing elliptical streamline (of mode $m=2$), which is centred on the galactic centre.

The 95 orbits shown in the animation were generated by C++ software. The software takes as input the starting parameters of just one of the orbits. It numerically integrates that orbit, and importantly also calculates its apsidal precession rate. From those results, the software automatically calculates numerous further orbits, choreographed to form the precessing elliptical streamline. The software then numerically integrates all the orbits, and outputs a sequence of many hundreds of video frames, from which the video is constructed.

Each of the 95 stars illustrated has its own orbit. The 95 orbits are all different to each other, However they all have exactly the same orbital period, and are coordinated so that all the stars belonging to this streamline always move along the elliptical streamline loop, and never collide.

The motion of each star is the sum of:
(A) the star's motion around the streamline, and
(B) the simultaneous precession (rotation) of the streamline shape.

The traced orbit of one of the stars is highlighted in red. This demonstrates the remarkable relationship between a streamline, and individual orbit of one of the stars which belongs to the streamline.

During the animation, each of the stars completes about three and a half galactic orbits, and simultaneously the streamline precesses in the prograde direction by approximately one galactic orbit.

Version history:

Version 1: 29 Dec 2014.
Version 2: 03 Jan 2015 Added link to video.
Version 3: 04 Jan 2015 Removed link to the Java animation, and reworded article.
Version 4: 10 Jan 2015 Updated link to video.
Version 5: 30 Apr 2015 Updated link to video, and improved the text.