Comets and the Sinusoidal Potential

by

David F. Bartlett

Brian Marsden

“One of the most influential comet investigators of the 20th century”
Matese & Whitmire’s Expected Modulation in Galactic Latitude

Fig. 3.—Distribution of the latitudes of perihelia in Galactic coordinates for class I Oort cloud comets. A random distribution would be uniform in $\sin b$. The arrows mark the bisectors of the predicted minima in the distribution. The north-south Galactic asymmetry may be caused by historical selection effects resulting from a deficiency of geocentric southern hemisphere observers (Delsemme 1987).
Fig. 2.—Distribution of the longitudes of perihelia in Galactic coordinates for class I Oort cloud comets. A random distribution would be uniform in $l$. The arrows mark the bisectors of the predicted minima in the distribution when the radial tide is included.
Do Comets Get a Nudge from the Galaxy?

But Marsden thinks the comet data just aren’t good enough to support Matese’s and Whitmire’s analysis. “I have no problem with [their] theoretical analysis,” he says, “but it’s a miserable, crummy set of data ... I say that having provided a lot of that data myself.” With better data or a different analysis, Marsden says, the effect might disappear—and another way for the galaxy to pluck comets from the Oort cloud might emerge.

—Charles Seife

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Sinusoidal Potential with a Graviton having an imaginary mass - \( m = 10^{-25} \text{eV} \)

Modified Gravitational Potential

\[
\Phi = -\frac{GM}{r} \cos(k_0r) \quad \nabla^2 \Phi + k_0^2 \Phi = 4\pi G \rho \\
\lambda_0 = \frac{2\pi}{k_0} = 400 \text{pc} \\
k_0^2 = \frac{E_H^4 4\pi G}{4}
\]

Here \( \lambda_0 \) is a universal wavelength. For \( r = 1\text{AU} \), \( \cos(k_0r) \) differs from 1 by only 1 part in \( 10^{-14} \), making it too small a difference to have been detected in the motion of the planets. If \( k_0r > 1 \), then the sinusoidal potential provides both a gravitational force and a tidal force which fall off as \( 1/r \). The slow fall off in \( r \) can explain the flat rotation curves of stars in disk galaxies.
Sinusoidal Potential Cont.

\[ \Phi = -\frac{GM}{r} \cos(k_0 r) \]

Top View of Dust and Stars in the thin disk
Hill Sphere for Sun and Galaxy is 1 Light Year

GR Correction falls off as $1/R$

Sun-sinusoidal increases as $R^2$

Galactic radial tides increases as $R^3$

Figure 5. Forces in the solar system: ratio of other forces to the Newtonian force of the Sun. The top of the graph represents equality. $R^S$ is the Schwarzschild radius of the Sun. A light-year is about the outer radius of the Oort cloud. $\lambda_0 \simeq 200$ light-years.
## Milky Way: Periods at Solar Circle

<table>
<thead>
<tr>
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<th>Conventional</th>
<th>Sinusoidal</th>
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<tbody>
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<td>Poisson’s Eq.</td>
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<td>Orbital</td>
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<tr>
<td>Radial</td>
<td>170 Myears</td>
<td>10 Myears</td>
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<tr>
<td>Z</td>
<td>62 Myears</td>
<td>200 Myears</td>
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The New Comets

Point A – Minimum semi-major axis for which the galactic tidal force exceeds the solar force at some point in the rapid (8MYear) epicyclic oscillation of the sun in groove of the alternating galactic potential.

$R_{1/2}$ - Resonance of 1 solar galactic epicyclic oscillation with two periods of the comet about the sun. (Kepler’s I assumed for the orbit of the comet about the sun.)
Use Compressive Radial Tide to Remove Max $\dot{H}$ from Orbit

To GALACTIC CENTER

45° = ANGINPLNX

$F$ and $F'$
Definition of ANGINPLNX

To GALACTIC CENTER

ANGLINPLNX
Far Oort Comets Quality 1A Only

Favored Galactic Longitudes for Radial Tide shown in red

Perehelion North of Plane of the Galactic Disk shown in red

Longitude, l

Sine of gal latitude
Far Oort Cloud. Quality 1A only

Angle in Plane for Compressive Tide (red)

Angle in Plane for Expansive Tide (blue)

ANGLEINPLN X

ANGLEINPLN Y

ANGLEINPLN Z
Far Oort Cloud. Distribution in Ecliptic Longitude & Latitude

Ecliptic longitude

Sine of Ecliptic latitude
Trans-Jovian Comets (q>5 AU)

Favored Galactic Longitudes for Radial Tide

Perehelion North of Plane of the Galactic Disk
Trans-Jovian Comets

Angle in Plane for Compressive Tide

Angle in Plane for Expansive Tide
Trans-Jovians. Distribution in Ecliptic Longitude & Sine of Latitude
Any Way You Slice It, Radial Tides Beat Z-Tides

Direction Cosines Between the Galactic X,Y & Z Axes and the direction to the cometary perihelion are l, m, n.

Marsden and others have Computed orbits for 499 Comets. All of these enter this tabulation.

Tabulation is broken into 13 separate averages.
Trans-Jovian Comets (q>5 AU)

- Quality \( <l^2> <m^2> <n^2> \) Number

- All \( .46 \ .29 \ .25 \ 55 \)

- Recall that max H is removed from cometary orbit when direction of tidal force is in plane of cometary orbit and is at 45 degrees to aphelion direction Q.
Unbound Comets (1/a < 0)

- Quality  $<l^2>$  $<m^2>$  $<n^2>$  Number
- 1A  .42  .31  .26  8
- 1B  .37  .34  .29  12
- 2A  .29  .36  .35  12
- 2B  .50  .36  .13  3
Far Oort Comets
(0 < \(1/a\) < 0.0001 AU\(^{-1}\))

<table>
<thead>
<tr>
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<th>(&lt;l^2&gt;)</th>
<th>(&lt;m^2&gt;)</th>
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<td>1B</td>
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<td>.36</td>
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Near Oort Comets
(0.0001 < 1/a < 0.002 AU^-1)

<table>
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<th>〈l^2〉</th>
<th>〈m^2〉</th>
<th>〈n^2〉</th>
<th>Number</th>
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</thead>
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<tr>
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<td>.41</td>
<td>.32</td>
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<tr>
<td>2B</td>
<td>.46</td>
<td>.31</td>
<td>.22</td>
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Contours of Sinusoidal Potential $\Phi(r,z)$ out to Sun’s Position ($r = 20 \, \lambda$)

22 mass rings with mass falling off as $r \exp[-r/7\lambda]$. In the plot, the black color is a potential minimum and white color is a potential maximum. Note: As viewed from the $z$ direction there is no clean view through material. (ie it is hard to observe the ring structure)
Contours of Sinusoidal Potential $\Phi(r,z)$ near Galactic Center

22 mass rings placed in median plane with mass falling off as $r \exp[-r/7\lambda]$. In the plot the black color is a potential minimum and white color is a potential maximum.
Butler Burton has stated that the “central wiggles are real” (private communication). He also notes in the plot he assumed a distance from the sun to the galactic center of $R_0 = 10 \text{kpc}$. The step structure is equal to $R_0/20$. 
CO is an observable substitute for the H2 needed for star formation. There are two dense bands of contours in this plot from Tom Dame et al (1987). These bands are approximately +/- \(\lambda/4\) and are probably related to stall points in the z-motion of matter in the extreme disk.
Thanks to John Cumalat
Spiral arms and oblique viewing angles usually suppress evidence of circular structure in external galaxies. Here the disk is thin enough and active enough for such structure to be evident. (The radius of the outer ring is about 2λ.)

NGC 7742 is a face-on unbarred spiral galaxy in the constellation Pegasus. The galaxy is unusual in that it contains a ring but no bar.[4] Typically, bars are needed to produce a ring structure. The bars' gravitational forces move gas to the ends of the bars, where it forms into the rings seen in many barred spiral galaxies. In this galaxy, however, no bar is present, so this mechanism cannot be used to explain the formation of the ring. O. K. Sil'chenko and A. V. Moiseev proposed that the ring was formed partly as the result of a merger event in which a smaller gas-rich dwarf galaxy collided with NGC 7742. As evidence for this, they point to the unusually bright central region, the presence of highly-inclined central gas disk, and the presence of gas that is counterrotating (or rotating in the opposite direction) with respect to the stars.