The Shape of a Storehouse Nobody Has Seen Was Fixed Not by Its Contents but by the Directions of What Arrived

— if the source is a spherical shell the cosine of the inclination is uniform and retrograde orbits are exactly **0.500000**, so **200** comets stand **22.0454** standard errors from a disc — the separator is whether a shape is seen or read from the directions of what arrives — [Paper 689]

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— From thinking to syncing. —

Abstract

The Oort cloud has never been observed directly. That it can still be called a spherical shell follows from the directions carried by the comets that arrive.How far a distribution of directions fixes a shape is counted here from the side of the sample size.No new theorem or law is claimed. First, and this is the core. A shell and a disc differ completely in direction——a shell gives 0.500000 retrograde and only 0.066987 below 30 degrees, while a disc puts almost everything below 30 (Section 2). **Second, the shell's distribution carries several memorable marks——exactly 0.250000 below 60 degrees, mean and median inclination both 90 degrees, and a variance of 1/3 in the cosine** (Section 2). **Third, so few samples decide it——the standard deviation of the cosine is 0.577350, so 200 comets give a standard error of 0.040825 and stand 22.0454 standard errors from a disc** (Section 3). **Fourth, the number required is startlingly small——separating them at 3 standard errors takes 3.703704 comets, that is four** (Section 3). **Fifth, even so, this is not the same as seeing the shape——a distribution of directions says only that the source is isotropic; it says nothing of distance, thickness or mass** (Section 4). **Sixth, the separator is whether a shape is seen or read from directions——when the shape of something unseen is fixed, what fixes it is not its contents but the directions carried by what arrived** (Section 4). **Keywords**: Oort cloud, distribution of inclinations, isotropy, standard error, inferring unseen structure, long-period comets.

Scope of this paper (scope note): **No new theorem or law is claimed——that the inclinations of long-period comets are nearly isotropic, and that a spherical source was inferred from this, are standard (Oort 1950, Duncan et al. 1987).No catalogue is used——nothing is fitted to a list of real comets; two idealisations, a shell and a disc, are compared.Origin is not treated——how the cloud was built by planetary scattering or galactic tides is not treated.No quantities are estimated——the mass, number and distance distribution of the cloud are not the subject.Selection effects are not included——no bias towards brighter comets is modelled; including one would raise the number required.Relation to earlier papers**: **Paper 337 set out the five edges of the solar system and stopped at the Oort cloud, stating in its scope note that it is not directly observed and that the figures are customary estimates——this paper enters where that one stopped, and puts a number on what supports the shape of a structure never observed.**What is added is **setting out the shell's distribution of directions in closed form**, **turning the standard deviation $\mathbf{0.577350}$ into a standard error for each sample size**, **putting the separation from a disc at $\mathbf{22.0454}$ standard errors**, **giving $\mathbf{3.703704}$ as the number needed for three**, and **placing the separator on seeing a shape against reading it from directions**.

1. Notation and the Question

Setting: **if the source is a spherical shell, the cosine of the inclination i of an arriving orbit is uniform on $[-1, 1]$. A disc crowds the inclinations towards zero.**

$$\Pr(i < \theta) = \frac{1 - \cos\theta}{2}, \qquad \mathbb{E}[\cos i] = 0, \qquad \operatorname{Var}[\cos i] = \frac{1}{3}, \qquad \mathrm{SE} = \frac{1}{\sqrt{3N}}$$

With 400000 random draws the variance of the cosine came out at 0.333679, agreeing with $1/3$.

Question: **how many samples fix the shape of something never seen?**

2. Shell and Disc Part Company in Direction

Computation 2.1: **the distribution of directions for a spherical shell was derived.**

quantity	value for a shell
fraction retrograde (inclination above 90 degrees)	0.500000
fraction below 30 degrees	0.066987
fraction below 60 degrees	0.250000
median inclination	90 degrees
mean inclination	90 degrees

With 400000 random draws the retrograde fraction came out at 0.499835 and the fraction below 30 degrees at 0.066757, agreeing with the closed forms.

> **Observation 2.2**
>
> **this is the core: the two shapes predict opposite values of the same quantity.A shell gives exactly half retrograde; a disc gives almost none——the two part company on direction alone, with no distance and no mass measured.**

> **Observation 2.3**
>
> **the distribution is marked at several memorable places.Exactly a quarter below 60 degrees, mean and median both 90——any one of these badly missed would drop the assumption of isotropy on the spot.**

3. How Many Are Enough

Computation 3.1: the standard deviation of the cosine is 0.577350. For each sample size, the standard error of the mean and the separation from a disc, whose mean cosine is about 0.9, were derived.

sample size	standard error of the mean	separation from a disc
10	0.182574	4.9295 standard errors
50	0.081650	11.0227 standard errors
200	0.040825	22.0454 standard errors
1000	0.018257	49.2950 standard errors

Computation 3.2: **separating the two at 3 standard errors takes 3.703704 comets, that is four.**

> **Observation 3.3**
>
> **what is needed is not a large sample but two predictions far apart.A separation of 0.9 against a standard deviation of 0.577350 is already a ratio above 1.5——each comet carries so much that ten of them reach 4.9295 standard errors.**

> **Observation 3.4**
>
> **so “known without being seen” is no miracle.What is unseen is the storehouse; every comet that arrived was measured one by one——a property of the unmeasured follows from the distribution of the measured. Nothing more than that is happening.**

4. The Separator

> **Observation 4.1**
>
> **the separator is whether a shape is seen or read from directions.A distribution of directions states only that the source is isotropic, and says nothing of distance, thickness or mass——the same word “shell” rests on different evidence when it comes from directions than when it comes from a picture.**

> **Observation 4.2**
>
> **beside Paper 337.Paper 337 set out five edges of the solar system and stopped at the Oort cloud, stating plainly that it is not directly observed——this paper enters where that one stopped, and shows that the evidence is not weak but of another kind. A scope note's "not treated" is the stock of the next paper.**

> **Observation 4.3**
>
> **what is not said.No catalogue, origin or mass is treated, and no selection effect is modelled——including one would raise the number required, and would not change that the two predictions are opposite.**

5. Roll Call and Closing

1. **retrograde 0.500000** (Computation 2.1): **half, for a shell.**
2. **below 30 degrees 0.066987** (Computation 2.1): **the core; a disc is the opposite.**
3. **below 60 degrees 0.250000** (Computation 2.1): **exactly a quarter.**
4. **mean and median 90 degrees** (Computation 2.1): **memorable marks.**
5. **random draws give 0.499835 and 0.066757** (Computation 2.1): **closed forms confirmed.**
6. **standard deviation 0.577350** (Computation 3.1): **from a variance of 1/3.**
7. **standard error 0.040825 at 200** (Computation 3.1): **each one counts.**
8. **separation 22.0454** (Computation 3.1): **decisive.**
9. **3.703704 for three** (Computation 3.2): **four comets suffice.**
10. **seen or read** (Observation 4.1): **the separator; Paper 337.**

Closing: **The shape of a storehouse nobody has seen was fixed not by its contents but by the directions of what arrived.A spherical shell gives exactly 0.500000 retrograde and only 0.066987 below 30 degrees, while a disc puts almost everything below 30——the two part company on direction alone.The standard deviation of the cosine is 0.577350, so 200 comets give a standard error of 0.040825 and stand 22.0454 standard errors from a disc.Separating them at three takes 3.703704 comets, that is four——what is needed is not a large sample but two predictions far apart.Even so this is not the same as seeing the shape——a distribution of directions states only that the source is isotropic, and says nothing of distance, thickness or mass.The separator is whether a shape is seen or read from the directions of what arrives.Placed among the earlier papers——Paper 337 stopped at the Oort cloud as**

not directly observed; this paper enters there and shows the evidence to be of another kind.To be honest——no catalogue or origin is treated and no selection effect is modelled.

References

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