Energy and the tessellated 3-sphere

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Abstract

The tessellation of space is considered for both the 2-sphere and the 3-sphere. As hypothesized in an earlier work, it is found that there is an energy associated with the 3-sphere.

1 Curvature and energy

For a method of calculating the curvature of triangle meshes and tetrahedron meshes, please see [1]. Unlike in [1], the tessellations in this paper will rely on pseudorandomly placed vertices, rather than the vertices placed by Marching Cubes and Marching Hypercubes. Also unlike in [1], we will not be compensating for the variation in simplex extent (e.g. do nothing special even where there are sliver simplices). The vertex count is N. Note that the Planck energy $E_P = 1.0$, and so the fundamental constants $c = G = \hbar = 1.0$ as well.

On one hand, it is found that for a tessellated 2-sphere, the local curvature vanishes when the tessellation is made up of finer and finer triangles. That is, the more vertices N used in the tessellation, the less the local curvature is:

$$\lim_{N\to\infty} K(N) = 0.0. \tag{1}$$

On the other hand, it is found that for a tessellated 3-sphere, the local curvature does *not* vanish when the tessellation is made up of finer and finer tetrahedra. The curvature settles around

$$\lim_{N\to\infty} K(N) = 0.284. \tag{2}$$

Unexpectedly, this is in line with the matter density measure Ω_M used in the xCDM models [2,3] – it is unknown if this is merely a coincidence. If it is not just a coincidence, then this is direct evidence of the discrete nature of space, based on a few simple, first principles. Note that curvature is proportional to energy:

$$K \propto E. \tag{3}$$

See Fig. 1 for a 3-sphere edge length histogram, where vertex count $N = 1,000,000$. Also see Table 1 for a list of properties of the histograms where the vertex count N is variable. A C++ code for generating the tessellated 3-sphere can be found at [4]. The code requires the qhull executables for mesh generation, the OpenCV library for plotting histograms, and the OpenGL / GLUT library for visualizing the vertices.

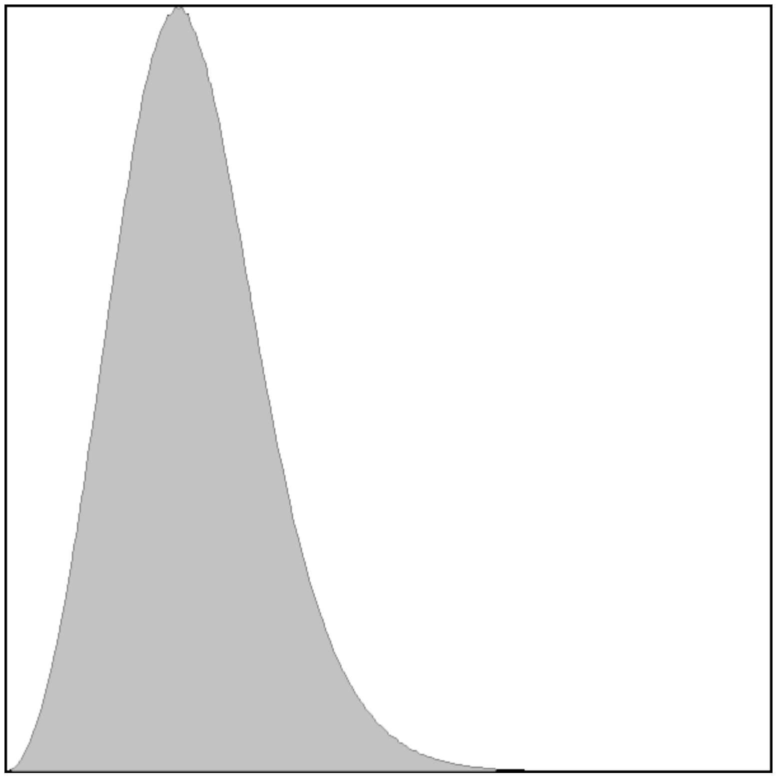

Figure 1: 3-sphere edge length histogram, where vertex count $N = 1,000,000$. Max = 0.0565194, mode = 0.012455. curvature K = 0.28452.

N	K	Max	Mode	Max / Mode
1,000	0.29473	0.405105	0.132555	3.05612
10,000	0.28821	0.215664	0.0619268	3.48256
100,000	0.28413	0.113452	0.0268951	4.21831
1,000,000	0.28452	0.0565194	0.012455	4.53788

Table 1: Properties of the histograms where vertex count N is variable.

References

[1] Halayka S. (2020) "The curvature and dimension of a closed surface"
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[3] Capozziello S., et al. (2006) "A fluid of strings as a viable candidate to the dark side of the universe" arXiv:astro-ph/0601266
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[4] Halayka S. (2020) "3-sphere Universe C++ code"
https://github.com/sjhalayka/4d_universe