Using metaballs to model the merger of Schwarzschild black holes

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Abstract

In this paper, Blinn's metaballs are used to model the merger of Schwarzschild black holes.

1 Metaballs

Metaballs have been used in computer graphics ever since their discovery by Jim Blinn.

Where $G = c = \hbar = k = 1$, there is an analytical solution for the merger of n metaballs (Schwarzschild black holes) travelling directly toward each other at non-relativistic speeds:

$$f(l) = \sum_{i=1}^{n} \frac{2M_i}{r_i}, \tag{1}$$

where M_i is the mass of the ith metaball, and

$$r_i = \sqrt{(l.x - v_i.x)^2 + (l.y - v_i.y)^2 + (l.z - v_i.z)^2}, \tag{2}$$

where l is the sample location, and v_i is the centre of the ith metaball. The isosurface (event horizon) is given by

$$f(l) = 1. \tag{3}$$

Included are figures of a black hole merger. The isosurface was tessellated using the Marching Cubes algorithm.

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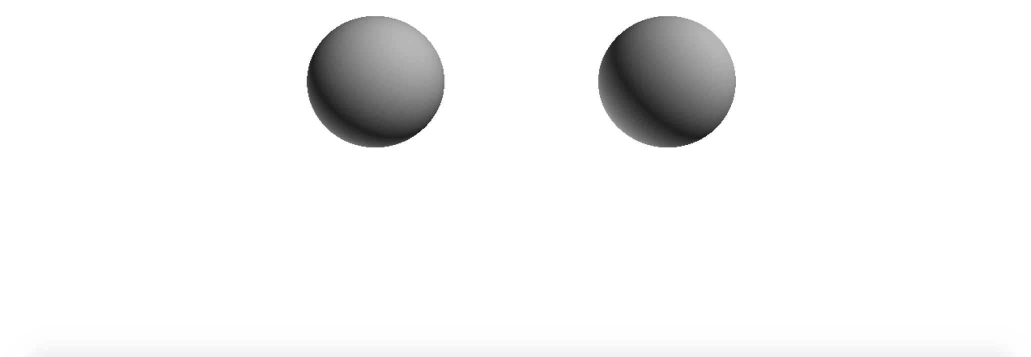

Figure 1: Two black holes of unit mass each, at a distance of 11.

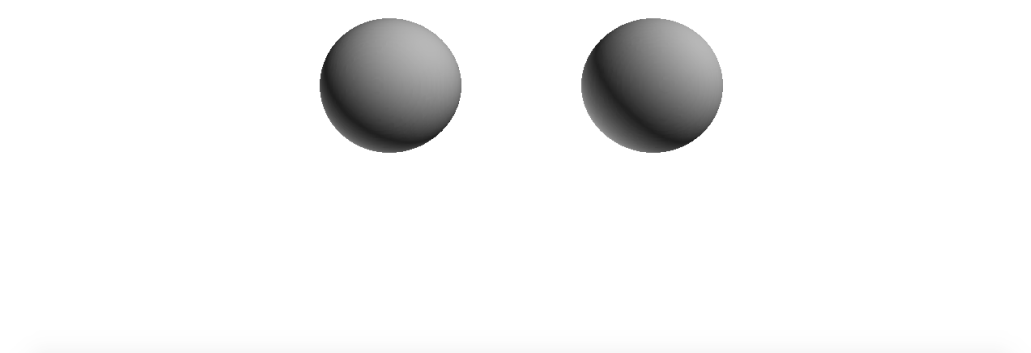

Figure 2: Two black holes of unit mass each, at a distance of 10.

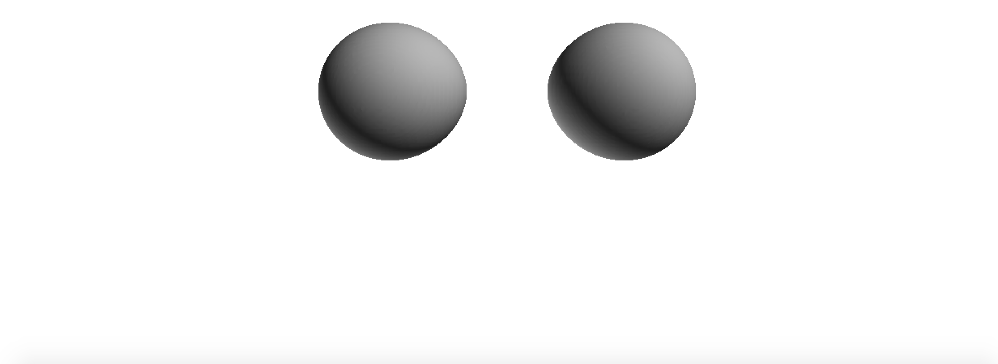

Figure 3: Two black holes of unit mass each, at a distance of 9.

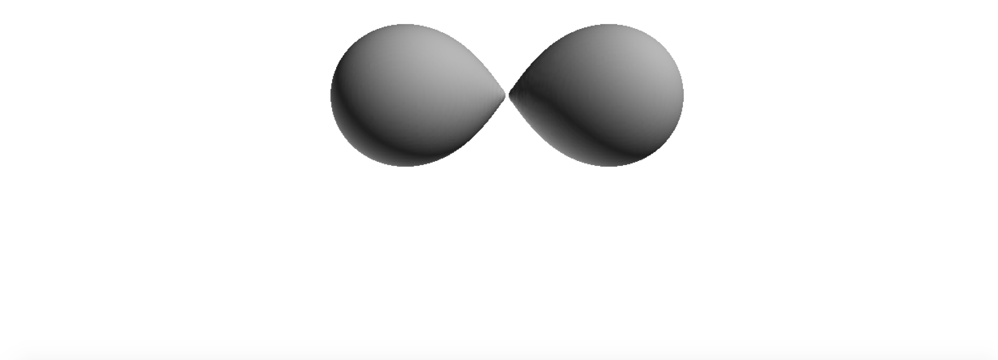

Figure 4: Two black holes of unit mass each, at a distance of 8.

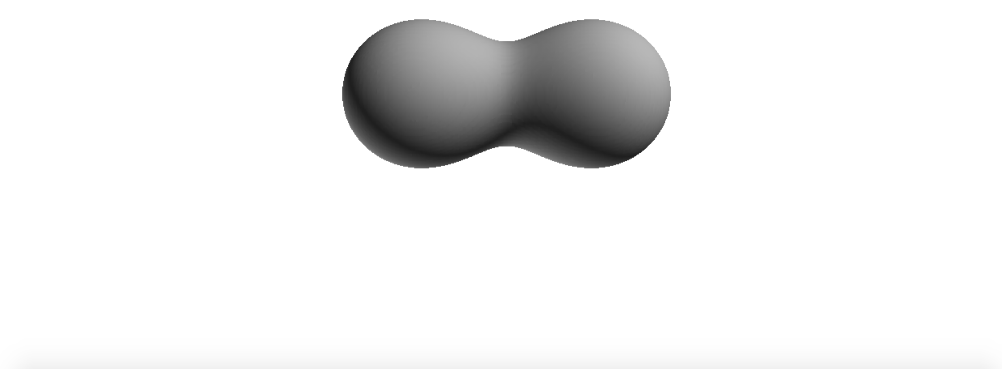

Figure 5: Two black holes of unit mass each, at a distance of 7.

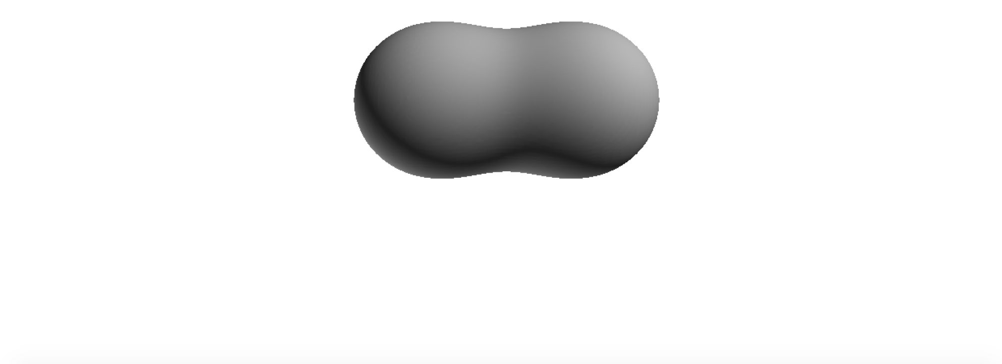

Figure 6: Two black holes of unit mass each, at a distance of 6.

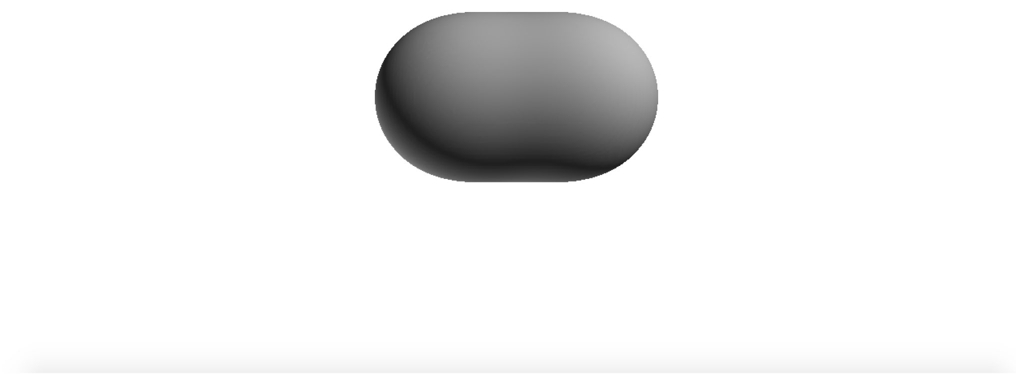

Figure 7: Two black holes of unit mass each, at a distance of 5.

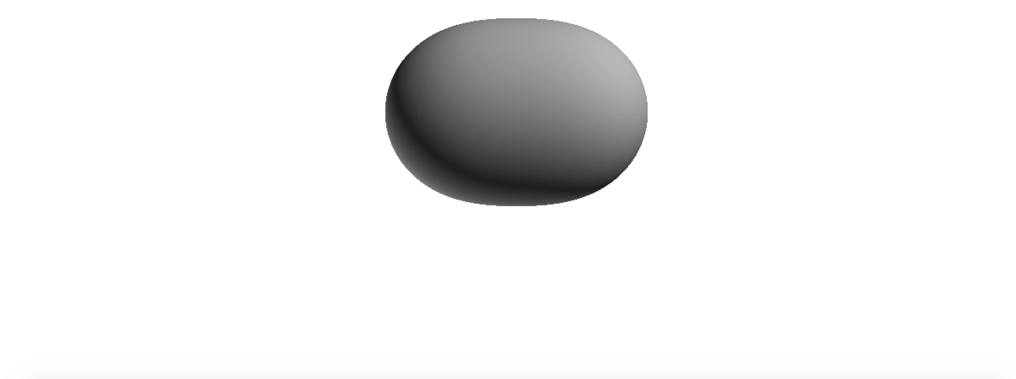

Figure 8: Two black holes of unit mass each, at a distance of 4.

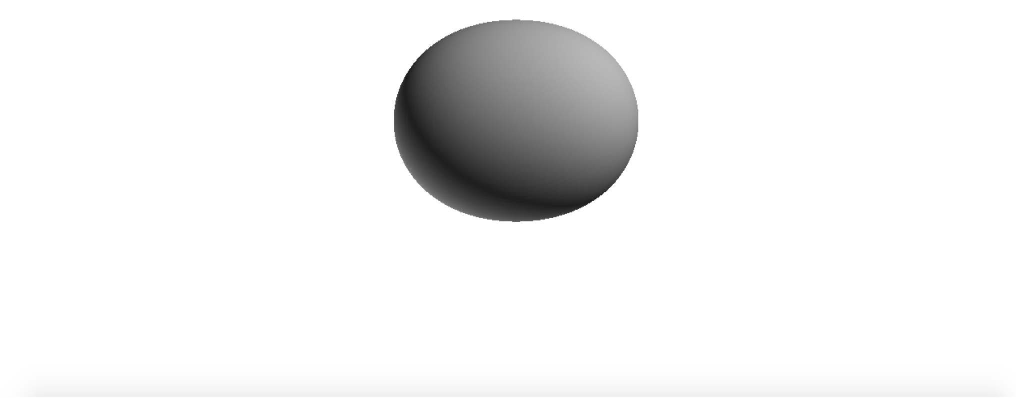

Figure 9: Two black holes of unit mass each, at a distance of 3.

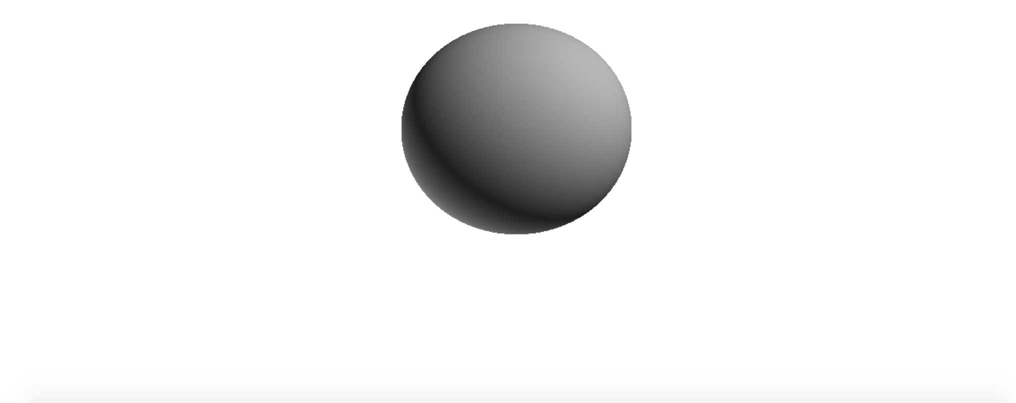

Figure 10: Two black holes of unit mass each, at a distance of 2.

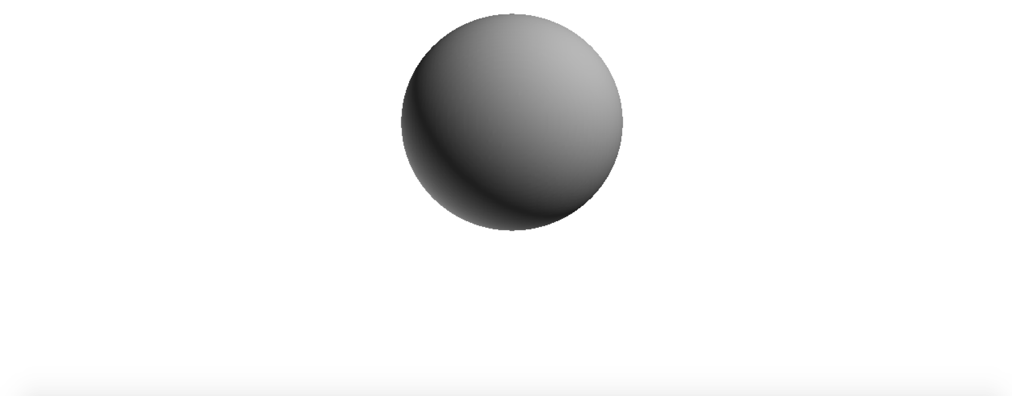

Figure 11: Two black holes of unit mass each, at a distance of 1.

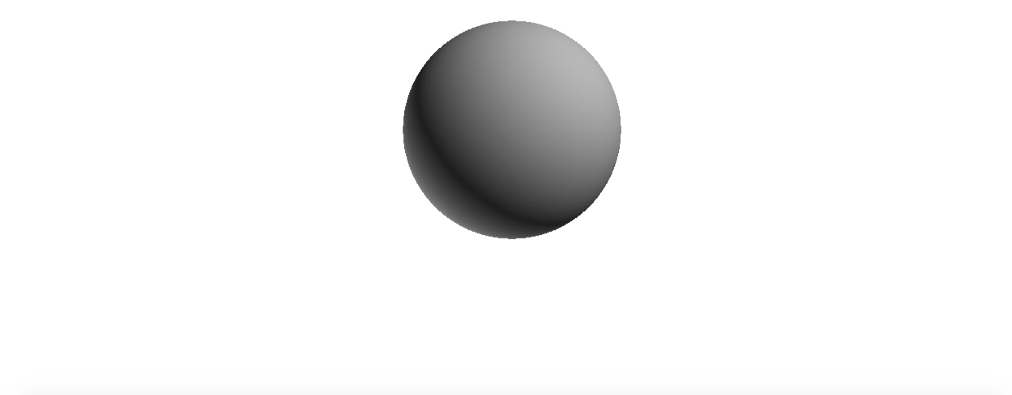

Figure 12: *One* black hole of mass = 2.

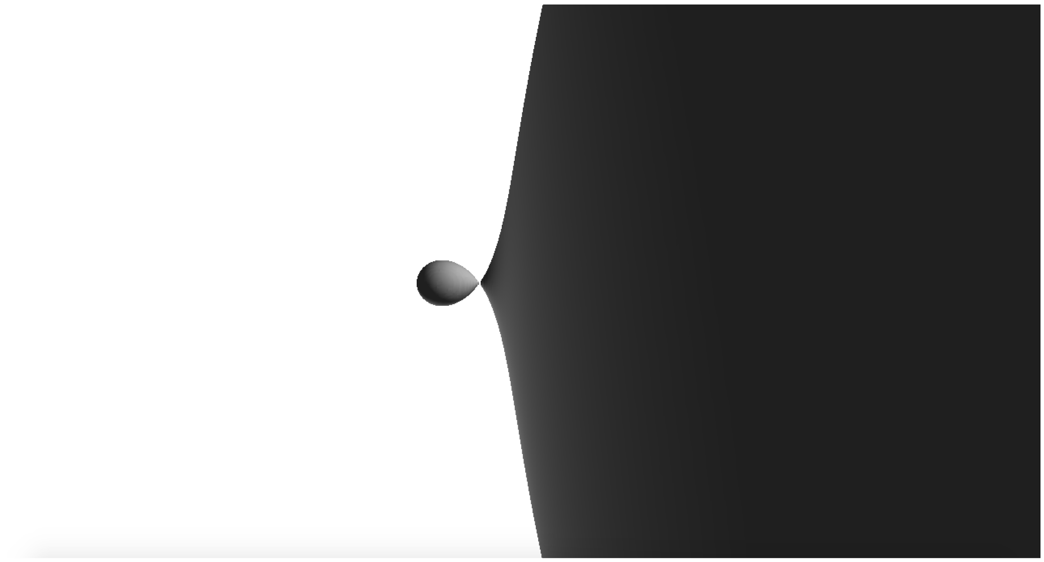

Figure 13: A unit mass black hole merging with a black hole of mass = 1000.

References

[1] Emparan R, Martinez M. *Exact event horizon of a black hole merger* (2016) arXiv:1603.00712 [gr-qc]

[2] Schutz B. *A First Course in General Relativity* (Cambridge: Cambridge University Press, 1985)