Spacetime Singularities

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Winter 2019

Meeting time: Wednesdays, 9:30-12:20pm, SST 442

Description: We will discuss a cluster of issues related to spacetime singularities, including: the global structure of spacetime in general relativity; the initial value formulation of Einstein's equation; black hole solutions; cosmic censorship; no-holes properties; inextendibility; and classical and quantum singularity theorems.

Requirements: The requirement for an S is regular attendance and participation. The requirement for a grade is (a) a full-length term paper (15-20) and (b) a ~1 hour presentation on the ideas for the paper during week 10 or 11.

Prerequisites: We will take for granted familiarity with the mathematical structure of general relativity, at the level of David Malament's book *Topics in the Foundations of General Relativity and Newtonian Gravitation Theory*.

Schedule:

Week 1: Preliminaries. Reading: Geroch & Horowitz (1979), §§5.1-5.2

Week 2: Global Structure. Reading: Geroch & Horowitz (1979), §§5.3-5.5

Week 3: Quasi-linear first order hyperbolic systems. Reading: Weatherall handout

Week 4: Black holes. Reading: Weatherall handout

Week 5: Strong cosmic censorship. Reading: Dafermos & Luk (2017), Part 1; Fletcher (2015)

Week 6: No meeting

Week 7: (No) Holes. Reading: Geroch (1977), Manchak (2012)

Week 8: Modality. Reading: Manchak (2019)

Week 9: (Quantum) singularity theorems. Reading: Wall (2013)

Week 10: Student presentations

Week 11: Student presentations

(Supplemental**) Readings:**

Earman, J. (1995). *Bangs, Crunches, Whimpers, and Shrieks: Singularities and Acausalities in Relativistic Spacetimes.* Oxford: Oxford University Press.

Fletcher, S. C. (2015). "Similarity, topology, and physical significance in relativity theory". *The British Journal for the Philosophy of Science*, 67(2), 365-389.

Dafermos, M., & Luk, J. (2017). "The interior of dynamical vacuum black holes I: The $ C^ 0$-stability of the Kerr Cauchy horizon." arXiv preprint arXiv:1710.01722.

Geroch, R. (1970), "Singularities," in M. Carmeli, S. Fickler, and L. Witten (eds.), *Relativity*. New York: Plenum Press, 259-291.

Geroch, R. (1977), "Prediction in General Relativity", in J. Earman, C. Glymour, and J. Stachel (eds.), *Foundations of Space-Time Theories*. Minnesota Studies in the Philosophy of Science, vol. 8. Minneapolis: University of Minnesota Press, 81-93.

Geroch, R. (1996). "The Partial Differential Equations of Physics". In *General Relativity*, ed. G. S. Hall. New York: Routledge. Pp. 19-60.

Geroch, R., and G. Horowitz. (1979). "Global Structure of Spacetimes." In *General Relativity*, ed. S. W. Hawking and W. Israel. Cambridge: Cambridge University Press. Pp. 212–93.

Hawking, S. W., & Ellis, G. F. R. (1973). *The Large Scale Structure of Space-Time*. Cambridge: Cambridge university press.

Malament, D. (2012). *Topics in the Foundations of General Relativity and Newtonian Gravitation Theory*. Chicago: University of Chicago Press.

Manchak, JB (2012). "On Spacetime Singularities, Holes, and Extensions". *Philosophy of Science,* 81: 1066-1076.

Manchak, JB (2019). "General Relativity As a Collection of Collections of Models." Forthcoming in *Hajnal Andreka and Istvan Nemeti on Unity of Science,* Judit Madarasz and Gergely Szekely (eds.), Springer.

O'Neill, B. (1995). *The Geometry of Kerr Black Holes*. Wellesley: A K Peters.

Wald, R. (1984). *General Relativity*. Chicago: University of Chicago Press.

Wall, A. C. (2013). "The generalized second law implies a quantum singularity theorem". *Classical and Quantum Gravity*, 30(16), 165003.