

Fifty years of the flatness problem

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Perception

(from conversations,

textbooks, papers)

- One of the most important problems in classical cosmology.
- Inflation solves the flatness problem.
- The Universe is very flat.
- The flatness problem and/or the flat Universe is evidence for inflation.
- The descriptions which most have heard are valid.
- No-one of any standing has seriously questioned the flatness problem.

My take

- One of the most important problems in classical cosmology. **No.**
- Inflation solves the flatness problem. **It can.**
- The Universe is very flat. $|\Omega_0 + \lambda_0 - 1| \lesssim 0.01$.
- The flatness problem and/or the flat Universe is evidence for inflation. **No.**
- The descriptions which most have heard are valid. **No.**
- No-one of any standing has seriously questioned the flatness problem. **No.**

Hall of fame

- Cho & Kantowski, *Physical Review D*, **50**, 6144 (1994): “distorted distribution of Ω values that sometimes misleads the casual observer”
- Coles & Ellis, *Is the Universe Open or Closed* (1997): “there is no flatness problem in a purely classical cosmological model”
- Rindler *Relativity: Special, General, and Cosmological* (2001): “the so-called ‘flatness problem’—the alleged improbability of finding the value of Ω_0 even within a factor of 10 of unity”
- Kirchner & Ellis, *Classical & Quantum Gravity*, **20**, 1199 (2003): “solve the flatness problem”
- Lake, *Physical Review Letters*, **94**, 201102 (2005): “there are an infinity of standard . . . FLRW dust models for which $\Omega \sim 1$ ”
- Adler & Overduin, *General Relativity & Gravitation*, **37**, 1491 (2005): “ Ω_T is *not* a useful flatness criterion”

Further reading

- R. Brawer: *Inflationary cosmology and horizon and flatness problems: The mutual constitution of explanation and questions*, master's thesis, MIT (1996) (<http://hdl.handle.net/1721.1/38370>)
- C. D. McCoy: 'Does inflation solve the hot big bang model's fine-tuning problems?' *Studies in History and Philosophy of Modern Physics*, **51**, 23 (2015)
- M. Holman: 'How Problematic is the Near-Euclidean Spatial Geometry of the Large-Scale Universe?' *Foundations of Physics*, **48**, 1617 (2018)
- P. Helbig: 'Arguments against the flatness problem in classical cosmology: a review', *European Physical Journal H*, **46**, 10 (2021)