

Part III: About Time, Paul Davies

23. READ:

- Prologue in *About Time*, Paul Davies.
- “A very brief history of time,” Chapter 1 in *About Time*, Paul Davies.

COLLATERAL READING:

- “Longitude,” by Dava Sobel, QB 225 .S64 1995
- Introductory sections of “Cosmic Evolution in a Cyclic Universe,” by Paul J. Steinhardt and Neil Turok, <http://arxiv.org/abs/hep-th/0111098>

DEFINE:

- rationalism
- empiricism
- the “cosmic-age problem”

ANSWER:

- What is the current best estimate for the age of the Earth?
- Does time equal motion? If not, how do we actually measure time?
- Do you feel that the flow of time is inexorable? Why or why not?
- If you took a new deck of 52 cards, with the cards grouped in suits and ordered, how many *perfect* shuffles would it take for the deck to return to its initial, ordered, state? A perfect shuffle is where the deck is split in two piles, and then one pile is formed by taking one card at a time from alternate half-piles.

24. READ:

- “Time for a change,” Chapter 2 in *About Time*, Paul Davies.

ANSWER:

- In discussing the Hulse-Taylor pulsar, we didn’t calculate the density of a neutron star. Calculate the density of a single neutron, and compare that to the observed density of a neutron star.
- Calculate the surface gravity of a neutron star — i.e., show that it can spin rapidly and not have material fly off.
- Comment on Davies’ claim on page 47 that “Newton’s universal time is a fiction.”

EXTRA CREDIT:

- One derivation of the relativistic factor γ can be found in nonrelativistic situations as well. The following “explanation” of the Michelson-Morely experiment described on page 50 was one of the first.

Consider a river flowing with speed v , and a swimmer able to swim at speed c relative to the water. (a) Calculate the time t_u it takes the swimmer to swim a distance d upstream and back, where d is the distance measured relative to the stationary river bank. (b) Calculate the time t_a it takes the swimmer to swim a distance d directly across the river and back (perpendicular to the river bank). (c) Show that the ratio of the two times (t_u/t_a) is equal to γ .

25. READ:

- “Timewarps,” Chapter 3 in *About Time*, Paul Davies.

WRITE:

- a paragraph on the history of the idea of “tachyons,” e.g., who coined the term? when? why?

ANSWER:

- What is the current model for Cygnus X-3?
- List the three arguments that Davies makes to show that gravity affects time.
- One experiment that Davies doesn’t mention was by Joseph Hafele and Richard Keating in 1971. Besides gravitational time dilation, what did they measure? Did their results agree with Einstein?

EXTRA CREDIT:

- Calculate the time difference measured by a clock carried by an astronaut on the International Space Station for one year compared with a clock on the Earth’s surface at the equator. Assume that the ISS is in an equatorial orbit at 300 km altitude. HINT: Because the speeds are so small, the binomial expansion of γ will be useful.
- On page 82, Davies states, “At a hundred million trillion electron volts, a single proton packs the same punch as a pitched baseball...” What does he mean? The same energy? momentum? Prove your answer with a calculation.

26. READ:

- “Black Holes: Gateways to the End of Time,” Chapter 4 in *About Time*, Paul Davies.

WRITE:

- a short biography of Martin Kruskal.

ANSWER:

- What pulsar did Jocelyn Bell (and Anthony Hewish) discover?
- What does “beyond the end of time” mean to you?
- What was there so much initial confusion concerning “quasi-stellar objects” (QSOs)?

27. READ:

- “The Beginning of Time: When Exactly was it?” Chapter 5 in *About Time*, Paul Davies.

28. READ:

- “Einstein’s Greatest Triumph?” Chapter 6 in *About Time*, Paul Davies.

DEFINE:

- Einstein ring. Find a good example of one.

ANSWER:

- Investigate the current status of either Stephan’s Quintet OR the pair Markarian 205 and NGC 4319. Is Halton Arp right and something is wrong with the Hubble Law? Or are they just chance associations on the sky?
- If the universe consisted of only sun-like stars, what must the average density of “suns” be to exactly match the “critical density,” $\rho_c = 9.47 \times 10^{-27} \text{ kg/m}^3$?
- Find the current best observational estimates to the Hubble constant, and who champions each value.

29. READ:

- “Quantum Time” Chapter 7 in *About Time*, Paul Davies.

DEFINE:

- Quantum Zeno effect
- quarter wave plate
- birefringence

ANSWER:

- Niels Bohr once said, “No phenomenon is a phenomenon until it is an observed phenomenon.” He also said “Nothing exists until it is measured.” Relate these statements to the discussion on pages 172-173.
- Explain the EPR paradox. What was Einstein’s view of reality?

30. READ:

- “The Emergence of Time and Its Arrow from Timelessness,” Julian Barbour.

DEFINE:

- pernicious
- solipsism

ANSWER:

- How does Barbour’s idea of pictures aligned on a rod compare with Davies’ concept of pigeonholes on pages 41-42 of *About Time*?
- What do you think of Barbour’s idea that configurations do not occur *at* instants of time *are instants themselves*?