Midterm exam

NAME: _____ **SCORE:** _____

Subject: Introduction to Astrophysics and Cosmology
Date: Friday 20th of January 2023
Duration: 120 minutes
Credits: 24 points, Type of evaluation: Midterm

This exam consists of closed-book concept questions. Provide answers to the following items. Each question is 1 point.

1. Name two of the distance units commonly used in astrophysics. Briefly explain how they are defined.
   - astronomical unit: distance between the Earth and the Sun
   - parsec: the distance under which an object would have 1" paralax.

2. Name 5 methods to measure distances, also mention to what scales the method can be used (e.g. within the galaxy, nearby galaxies, distant galaxies)
   - parallax: nearby stars (galaxy)
   - globular clusters: nearby galaxies
   - variable stars (period-luminosity relation): nearby galaxies
   - Ia supernovae: distant galaxies
   - hubble flow: distant galaxies

3. Name 2 methods of observing gravitational waves.
   - LIGO type interferometers
   - binary pulsars -> orbital properties

4. Which are the 3 different types of magnitudes? Briefly explain what each one is.
   - apparent: visible magnitude of objects
   - absolute: magnitude at 10 pc
   - bolometric: all wavelengths

5. Name 2 sources of astronomical information that are not electromagnetic waves.
   - gravitational waves
   - neutrinos
   - cosmic rays

6. Which 4 concepts do the basic stellar structure equations describe?

- mass conservation
- hydrostatic equilibrium
- energy conservation
- energy transport

7. What phenomena can happen inside a star if there is a steep temperature gradient?

convection if the Schwarzschild criteria is satisfied

8. What does the Saha equation describe?

fraction of ionised atoms

9. What is the main simplification used to solve stellar structure models? Briefly explain.

grey atmosphere model → assumes that in a layer the absorption coefficient is constant for all frequencies.

10. Do stellar models have unique solutions? What is the reason for this?

No. We can get solutions for regular stars and degenerate stars for the same initial parameters.

11. How does the lifetime of a star relate to the mass of the star?

Larger mass → shorter life

12. What is the energy production mechanism inside main sequence stars?

hydrogen fusion into helium

13. What can we learn from neutrinos about the Sun?

We can get information about the nuclear fusion happening inside the core.

14. What is asteroseismology? What can we learn from it?

We can map the density distribution inside stars based on the oscillations of the surface.

15. What are sunspots?

Sunspots are colder regions on the surface of the Sun that appear as dark spots. They are locations of magnetic flux tubes → they are related to the magnetic field of the Sun.

16. What is the solar cycle? How long is the solar cycle?

A change in the number of sunspots and the polarity change of the magnetic field define the solar cycle. The full cycle is 22 years long.

17. What are the 3 options for the end state of regular stars?

- white dwarf
- neutron star
- black hole

18. What is a pulsar and a millisecond pulsar?

A pulsar is a rotating neutron star, where the jet occasionally points towards Earth. A millisecond pulsar has a very fast period. These are neutron stars in a binary system accreting material from a companion star.

19. How does the radius change with mass for degenerate stars? What does this imply?

the radius becomes smaller with increasing mass → there is a mass limit: the Chandrasekar mass, which can not be exceeded.

20. What is the origin for a Ia type supernova? Why are these types of supernovae important?

Ia supernovas are the result of mass transfer onto a degenerate star, which explodes after reaching a critical mass. Because they have the same mass at the explosion → they have the same brightness → distance measurment.

21. What are the basic structural components of our Galaxy where the stars are distributed in? Name 4.

- disk
- bulge
- globular clusters
- halo

22. How do we know that the Milky Way is a spiral galaxy?

- density distribution measurments of stars
- density distribution measurment of gas

23. Why is the interstellar reddening?
the dust in the interstellar medium makes the light from stars look redder

24. How do stars move in the disk of the Milky Way? Briefly explain.
stars move on approximately circular orbits ~~in~~ in the disk. This is an epicyclic motion.
Stars in the spherical components ~~move~~ have random motions

25. What is a rotation curve, and what shape does it have for typical spiral galaxies? What can we learn from this?
the rotation curve is the circular velocity in the disk of a galaxy with respect to radius. Rotation curves have a flat shape for spiral galaxies → indication of dark matter.

26. Which stellar populations are there? What are the characteristics of them?
population I. young stars, ISM, metal rich
population II. old stars, no ISM, not much metals
population III. oldest stars, no metals

27. Which are two main phases of neutral hydrogen in the Galaxy? How can we observe them?
– cold HI : in absorption

– warm HI : in emission

28. Which molecular species do we observe if we would like to map the molecular gas in the Galaxy? How is the molecular gas distributed in the Galaxy?
We usually observe CO. CO is distributed mostly in the disk of our Galaxy in molecular clouds

29. What are HII regions?
Regions of ionized hydrogen around young stars. They have usually a circular shape.

30. How do we know that the Galaxy has a magnetic field?
– polarization measurements
– synchrotron radiation from cosmic ray particles

31. What types of environments do galaxies appear in? Name 3.
- clusters
- groups
- field

32. What are the characteristic of spiral galaxies? Name 4.
- disk shape
- lots of young stars
- interstellar medium (HI and molecular gas)
- star formation

33. What are the characteristic of elliptical galaxies? Name 4.
- elliptical shape
- only old stars
- no interstellar medium (or very little)
- no star formation

34. How is the neutral hydrogen distributed in spiral galaxies?
in a disk

35. Name 3 quantities that we can measure from the integrated HI profile (the HI spectrum) of a galaxy?
- amount of HI
- distance based on Hubble flow
- dynamical mass from the width of the profile

36. What is the result of a major merger of two spiral galaxies?
an elliptical galaxy

37. What will happen to a spiral galaxy in the long term if it losses most of its neutral hydrogen?
it won't be able to form stars and slowly turn into an elliptical galaxy.

38. What is and AGN? Briefly explain what components we can observe.

An AGN is a black hole at the centre of a galaxy that produces very intense radiation due to material accreting onto the black hole.
Components: black hole, accretion disk, dust and gas torus, fast moving clouds, slow moving clouds, jet.

39. What can we learn from the motion of galaxies inside a galaxy cluster?

→ the dynamical mass of the cluster → the presence of dark matter

40. What are the origins of gamma ray bursts (GRBs)? Name 2.

- core collapse supernovas
- merging neutron stars
- black hole - neutron star merger