UNIVERSITY OF CAPE TOWN
EXAMINATION ANSWER BOOK

FOLD

(Fold over on dotted line and seal with stickers supplied.)

Surname (In block letters) BALOI

First Name(s) NKATEKO

Student No. B L X N K A 0 0 2

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All answer books must be numbered

Number of books handed in	2
Number of this book	1

1	7	5	3	2	3	0

Date 9 June 2025

Degree/Diploma/Certificate for which you are registered (e.g. BA BSc) M Sc

Course code and description AST5003F
(to be copied from the heading on the Examination Paper)

Paper No
(to be copied from the heading on the Examination Paper)

Venue: AST Seminar Room

EVERY CANDIDATE MUST enter below the book number and the number of each question answered (in the order in which it has been answered); leave columns (3) and (4) blank.

1	2	3	4
Book Number	Question Number	Internal	External
1	3	9	
1	4	2	
1	5	11	
		22	
Examiner's Initials		SBP	

STUDENTS ARE TO READ THE IMPORTANT NOTES AND WARNINGS ON THE BACK COVER.

Any dishonesty will render the candidate liable to disqualification and to disciplinary action.

UNIVERSITY OF CAPE TOWN
EXAMINATION ANSWER BOOK

All answer books must be numbered

Number of books handed in	2
Number of this book	2

1	7	5	3	2	3	6

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1	2	3	4
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2	5		
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momentum due to a sudden change in trajectory due to the field lines.

Intermediate polars typically have asynchronous spin periods, which means the white dwarf tends to spin faster than the orbital period of the system. This is achieved from the accreting material onto the magnetic poles increasing the angular momentum of the white dwarf. The accretion does not ~~inf~~ infinitely increase the angular momentum of the white dwarf as this would cause the ~~spin of the~~ accreted material to 'fly away' from the pole. Hence the spin rate is regulated such that it is not too high to prevent accretion entirely.

The beat period comes from the ~~threaded~~ threading region before the material accretes onto the magnetic poles. This region becomes heated due to viscosity and emits radiation in the optical regime. The beat period is slower than the spin period due to the material lagging behind the white dwarf as it spins.

Some systems are able to show modulations in both spin and beat periods ~~due~~ as the accretion rate ~~and~~ from the threading region and accretion from the boundary wave modulations.

Fourier analysis breaks down the incoming signal into its base components where certain frequencies correspond to specific
5 sinusoidal waves that can be picked out.
Retrieving the ~~frequencies of~~ spin, beat and orbital frequencies allows for the extrapolation of their periods.

11

white dwarf as it accretes material, as well as the drag forces of the field lines, the material at the ~~f~~ magnetic poles is extended above the white dwarf forming a threading region.

The threading region consists of diffuse and 'blob' material that are affected by the ~~vis~~ viscous effects of the field lines. ~~Thus these regions can be heated to optical emission~~ This region ~~experiences~~ undergoes cyclotron radiation as the material spirals to the poles.

At the magnetic poles where accretion occurs, the accreting material slams into the surface of the white dwarf releasing large amounts of thermal energy in the form of ~~X-ray~~ x-ray emission.

6

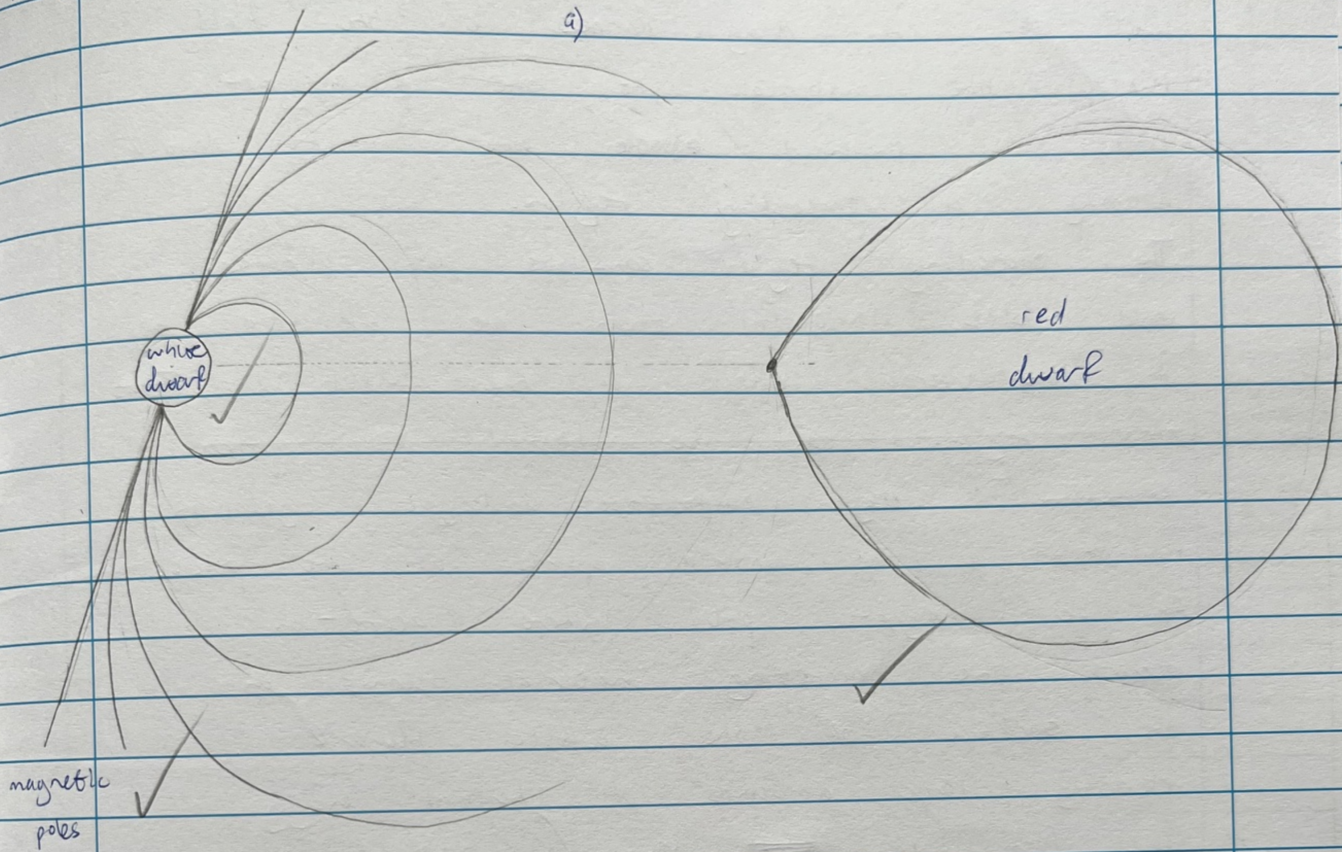
b)

Intermediate polars have weaker magnetic fields than AM Her stars. This allows for the formation of a disc as the radius of the magnetosphere is less than the ~~circulatation radius.~~ circulationary radius. However, ~~the~~ ionised material cannot cross the magnetic field lines.

At the boundary between the magnetosphere of the white dwarf and the accretion disc, the ionised material loses angular

Question 5

a)



An AM Her star is a white dwarf in a system where there is no accretion disc due to the strong magnetic field of the white dwarf such that the radius of the magnetosphere is greater than the radius of the circulatation radius.
This is not a detached binary as accretion still occurs without the disc.
As the ionised material from the secondary falls to the white dwarf, the field lines drag the material. ~~along the~~
The material then ~~accretes~~ accretes at the poles where ~~it~~ it is funneled into a small region. Due to the rotation of the

~~as mater~~ Material then begins to fill up the disc during quiescence to replenish the lost material.
The contraction of the accretion disc during an outburst with the expansion of the disc during quiescence supports the disc instability model.

0

c)

Nova-like cataclysmic variables exhibit outbursts like those seen in dwarf nova outbursts, with the exception that the outbursts last ✓ longer due to the accretion disc being more stable, allowing for a more gradual build up of thermal energy in the disc over time. The flux of these outbursts is lower than that of a dwarf nova outburst.

1

Z Cam stars and nova-like cataclysmic variables have an accretion model similar to that outlined by Geoff Bath where the secondary star causes changes in the accretion rate of the white dwarf.

2

magnet poles

It is clear that heat travels in waves throughout the disc.
The duration and formation of the dwarf nova outburst is dependent on the origin of the heating wave (i.e. starting from the inner disc or the outer disc) and the viscosity of the stellar material (more viscous material transfers heat more slowly).

b)

~~The disc instability model~~
During ~~quiescence~~ quiescence, material accrets onto the white dwarf from the accretion disc. For the case where the accretion rate is higher than what can be dissipated by the white dwarf, the rapid infall of material onto the white dwarf causes rapid increase of heating. This heating and infall of material generates increased instability of the accretion ~~of~~ onto the white dwarf where the build up of material triggers massive accretion onto the white dwarf. This sudden accretion leads to an outburst ~~of material where~~ where all the material is suddenly accreted, causing the disc to contract.

Question 4

a)

The disc instability model describes the accretion disc as having annuli of stellar material that orbit with different angular momenta due to their distance from the white dwarf. Annuli ~~far~~ in the outer disc have higher angular momentum than annuli in the inner disc.
The difference in angular momentum generate different speeds in each annuli, and friction between the annuli generates viscosity ✓ in the form of turbulence.
Hence the disc instability model paints the disc as being turbulent.

Changes in temperature affect the angular momentum of the charged particles due to changes in kinetic energy.
Since the disc ~~cons~~ consists of inner and outer layers, heating and cooling occur at different points of the disc ~~sim~~ simultaneously.
Consider the heating of the inner disc, as the heat is transferred to the outer layers the viscosity of the stellar material slows down the heating.
This causes a slow rise in temperature of the outer disc and results in a short burst of energy.

this k ~~thermal~~ ~~avg~~ energy due to collisions, so they continue to heat up.

For a low accretion rate, the ~~m~~ boundary layer continues to be heated as the region remains optically thin, but this boundary will expand towards the inner part of the accretion disc.

This forms a corona of optically thin material around the white dwarf.

Over time the inner cool disc becomes evaporated and feeds the corona.

As the density increases, more material falls to the surface of the white dwarf causing a ~~siphoning~~ siphon
7 effect where heated material from the accretion disc falls onto the white dwarf.

9

b)

Optically thick boundary layers are regions of high density of ionised material. These layers cause a decrease in the flux of the white dwarf due to increased scattering of light. These regions tend to show absorption of UV light. X

Optically thin boundary layers are less dense regions of ionised material. These layers are brighter in the optical regime than their optically thick counterparts. X

Optically thick regions emit radiation as black bodies when they are heated and will exhibit the spectral energy distribution of a blackbody. ✓

1

c)

An optically thin boundary layer consists of a low density of ionised material. ✓ During accretion, this material becomes heated due to the sudden breaking at the surface of the white dwarf. This change in kinetic energy is converted to thermal energy.

Since the boundary layer is optically thin, the ~~ions~~ charged particles are unable to lose ✓

1

7

9

Question 3

a)

~~The boundary layer is the boundary between the magnetosphere of the white dwarf and the accretion disc.~~
~~Ionised stellar material in the accretion disc is unable to cross ~~fi~~ the magnetic field lines, and are instead made to change direction due to the electric charge of the material interacting with the magnetic field.~~
~~The outer magnetosphere of the white dwarf cause a sudden change in direction to the infalling material.~~

a)

Material from the accretion disc does not immediately accrete into the white dwarf surface. ~~It~~ The inflowing material
1 slams into the surface and this abrupt change in trajectory produces thermal energy. The boundary layer between the surface and the disc is heated, though not as dramatically as the magnetic counterpart due to the angular momentum of the inner disc being slower than the outer disc.
For high accretion rates, the heated boundary expands to form a corona around the white dwarf, where material slowly diffuses from the disc to the corona.