

CUME 468

Total points: 45

Overview:

CUME 468 is inspired by the colloquium by Prof Nitin Yadav on vortexes in the solar atmosphere. For this CUME you will study a paper titled: “Solar Vortex Tubes: Vortex Dynamics in the Solar Atmosphere” by Silva et al. 2020, which forms the basis of some of the swirl detection algorithms mentioned in Prof Nitin Yadav’s talk. Pay special attention to section 1, section 3, section 4 and section 5.

There are four parts to the cume, covering the four sections that the students are expected to read (section 3, 4 and 5). Total points to be gained in the cume are 45, and passing is at 31.5 points.

Recommendations: Pay attention to the plots and figures in the paper.

Technical details: You will need pen, paper and calculators.

Contact: Via Zoom/chat on Canvas.

Part 1: Covers Section 1 [10 points]

Question 1: Name two vortex formation mechanisms described in the introduction. [2 points].

Question 2: Explain using 4-5 sentences how vortexes are formed at the downdraft centres [5 points]

Question 3: How are swirls (specifically chromospheric swirls) different from the other vortexes mentioned in the introduction [3 points]

Part 2: Covers Section 3 [11 points].

Question 4: As per the simulation in what plasma-Beta regime are the vortexes found? [1 point]

Question 5: A vortex with a solid body rotation has a tangential velocity given by: $V_{\theta} = \Omega r$ in equation (4)

where Ω is the angular velocity that is uniform and r is the vortex radius. Therefore, the tangential velocity would have a linear dependence with r in a rigid body rotation.

According to the authors solar vortices deviate from the above rigid body assumptions. What evidence do the authors present in the paper to suggest this deviation? How are these deviations different across different regions of the solar atmosphere [5 points]

Question 6: Describe how tangential velocities are different for vortex #7, #8 and #12. [5 points]

Part 3: Covers Section 4 (application of Section 3) [11 points]

Question 7: Summarise how the vortex #8 is different from other vortices mentioned in the literature. [3 points]

Question 8: What role does the strength of magnetic field play in formation of the vortices? How is this different from formation mechanisms described in Section 1 [5 points]

Question 9: You're given a plasma material that passes through a funnel created by a downdraft. To simplify, this plasma acts like an everyday fluid. The flow velocity is given by:

$$u = (x^2 + 2y)i - y^3 j - 3zk$$

Determine the vorticity of this plasma.

Hint, vorticity ($\omega = \nabla \times u$). You will have to use matrix multiplication to solve the problem. [3 points]

Part 4: Covers Section 5. [13 points]

Question 10: In observational solar physics, almost all chromospheric swirls are associated with the photospheric magnetic fields that form a vortex. However, the number density of the vortices in the photosphere doesn't match with the number density of the chromospheric swirls. There are nearly 100000 photospheric vortices present on the sun at any given time, but only 1000 chromospheric swirls. This leads to one of the biggest questions: where are the missing chromospheric swirls? What theory have the authors presented to answer this dilemma of the missing number of swirls? [5 pt]

Question 11: Section 1 introduces chromospheric swirls. These swirls are driven by concentrations of magnetic fields that form the vortices. The authors simulate vortices in the manuscripts.

A.) Compare the physical characteristics of simulated vortexes by the authors and the chromospheric swirls mentioned in the introduction. [2 points]

B.) How are the two phenomena associated with each other? [3 points]

C.) What are the limitations of the simulations while comparing the vortexes to the chromospheric swirls? [3 points]