

SP3176 The Universe TEST (AY21/22)

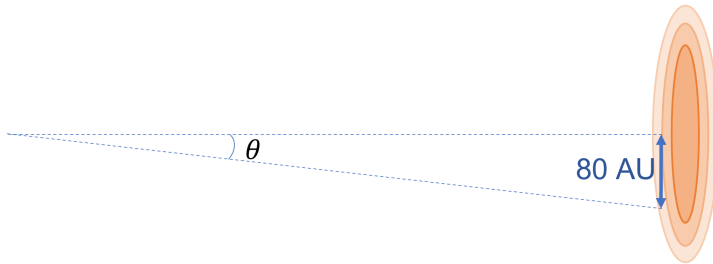
Questions for this test are related to the [1] stated as well related concepts covered in “The Universe” module. As far as possible, formulate the answers with your own words. Do not plagiarise from any sources, including the references below. Total marks of the test is 20, excluding the bonus question.

Question 1.

- (a) Glycoaldehyde had been detected in outer space before 2012. How is Jørgensen et al.’s detection in [1] significant? [1 mark]
- (b) What are some issues with the assignment of molecules to the spectral data? [1 mark]
- (c) Have the authors of [1] adequately addressed the above issues? Briefly justify your answer. [2 marks]

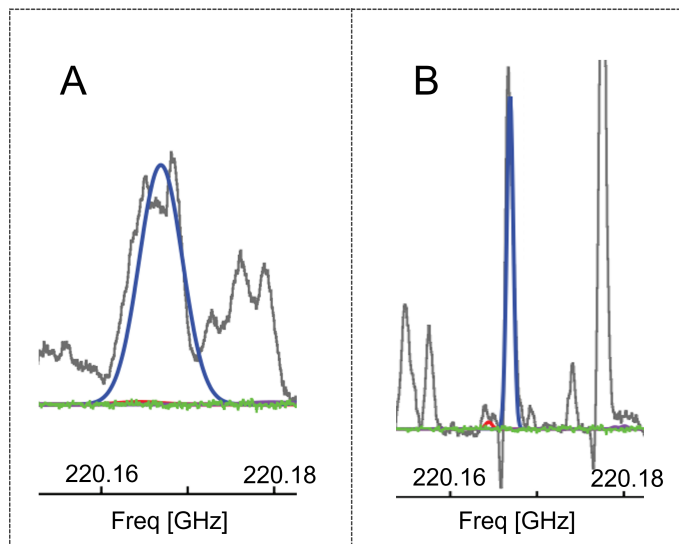
Question 2.

IRAS 169293A is located 120 pc away from us. Consider two points P_1 and P_2 in IRAS 169293A that are 80 AU apart (in our plane of view).



- (a) What is the angular separation between P_1 and P_2 ? [1 mark]
- (b) If a radio astronomer is to use a single dish radio telescope operating at 220 GHz, what is the minimum aperture size needed to resolve the two points? [1 mark]
- (c) If the astronomer uses the above telescope (one that can resolve P_1 and P_2 when operating at 220 GHz), but now operates at 690 GHz, what is the smallest separation that it can resolve? [1 mark]
- (d) What is the limitation of using higher frequencies (in this context)? [1 mark]
- (e) How is ALMA different from a single dish radio telescope? (No need to answer. Just read up for fun!) [0 marks]

Question 3.



(a) The figure above contains expanded parts of Figure 1 in [1]. Estimate the widths (FWHM) of the Gaussian fits (blue graphs) in GHz. [1 mark]

(b) Take a look at Figure 3 of [2]. Suggest a reason why the width of the spectral line in A is larger than that of B. Support your argument with simple calculations and numerical values. [3 marks]

Question 4.

With reference to Figure 3 of [1], the authors claim that the redshifted absorption profiles towards IRAS 16293B are indicative of molecules infalling towards the core of the protostar.

(a) Explain how an infall model can account for the spectroscopic results in Figure 3. You may use a sketch to help illustrate your point. [3 marks]

(b) Estimate the infall velocity. [1 mark]

Question 5.

(a) Describe the proposed mechanism that leads to the formation of glycolaldehyde in IRAS 16293B. [2 marks]

(b) The ratio of ethylene glycol to glycolaldehyde is $> 5 : 1$ in Hale-Bopp comet but $0.3 - 0.5 : 1$ in IRAS 16293B. Suggest a possible reason. [2 marks]

Bonus question.

In preparation for the test, you may have came up with your own questions. If you have thought of a good one and will like to share, please write down the question and answer. [Up to 2 additional marks]

References

- [1] Jorgensen, J. K., Favre, C., Bisschop, S. E., et al. 2012, ApJL, 757, L4
- [2] Pineda, J. E., Maury, A. J., Fuller, G. A. et al. 2012, A & A, 544, L7