SN EDUCATOR GUIDE

April 27, 2019

Kuiper Belt Dust

Student Activity Guide: Dusty Data Dive

Directions: After reviewing the general information about the data below with your teacher, look at Tables 1 and 2 and use them to answer the following questions. When needed, use an additional resource to find background information.

Table 1:

IDP #	Track Density Measured (Tracks/cm²)	Type of Mineral
1*	6×10^{10}	pyx
2	8×10^{10}	Ol
3	6×10^{10}	An
4	10×10^{10}	pyx
5	7×10^{10}	An
6	3×10^{10}	pyx
7	8×10^{10}	pyx
8	3×10^{10}	pyx
9	5×10^{10}	pyx
10*	7×10^{10}	pyx
11*	50×10^{10}	pyx, Ol
12	6×10^{10}	pyx
13	2×10^{10}	pyx
14*	6×10^{10}	pyx

Table 2:

Initial Distance of IDP from the sun (AU)	Estimated Track Density Computer Model 1 (Tracks/cm²)	Estimated Track Density Computer Model 2 (Tracks/cm²)
50	6.2×10^9	12.6×10^9
40	5.4×10^9	10.6×10^9
30	4.6×10^9	8.4×10^9
20	3.6×10^9	6.0×10^9
10	2.2×10^9	3.2×10^9
5	1.2×10^9	1.6×10^9
3	0.8×10^9	0.8×10^9

Background questions

1. Study the first column of Table 2. What does AU stand for and what does it measure? Convert 1 AU to two different units of measurement.

2. What are the approximate distances of the following objects from the sun in AU?

Mercury
Earth
Asteroid belt
Uranus
Kuiper Belt

3. According to the primary research study, dust from the asteroid belt would reach Earth in about 6 x 10^4 years, and dust from the Kuiper Belt would reach Earth in about 1 x 10^7 years. Use this information, Table 2 and your answer to the previous question to answer the following questions.

Approximately how many times further does dust from the asteroid belt need to travel to reach Earth compared with dust from the Kuiper Belt?

Approximately how many times longer does it take for dust from the asteroid belt to travel to Earth compared with dust from the Kuiper Belt?

How does the travel time appear to relate to the distance traveled?

4. How does your final answer to question 3 relate to the simple equation for diffusion? In simple diffusion problems, the distance a grain travels (L) depends on a diffusion constant (D) and the time (t) the grain has been traveling: $L^2 = Dt$, or $t = L^2/D$.

5. What is a benefit and a drawback of applying the simple equation for diffusion to try to understand how space dust travels?

Data analysis and graphing

6. In Table 1, do you see any obvious outliers in the data? What can you infer about the history of any outliers? Should they be used to draw more general conclusions about the data?

7. What is the average track density for the 10 anhydrous samples?

8. What is the average track density for the four hydrated samples?

9. What is the average track density for the hydrated samples without the outlier?

10. Does removing the outlier appear to have greatly affected the results? Explain.

11. Use graph paper, a computer or a calculator to graph the data from both computer models shown in Table 2. If both models are represented on the same graph, make sure your graph indicates that Computer Model 1 data is a separate series than Computer Model 2 data. What type of graph might you use?

12. Where would a data point for 1 AU fall on the Table 2 graph?

13. What is a simple, approximate equation that fits most of the data points for the Computer Model 2 data? If you graphed the data on the computer or calculator, use the graphing system to find an equation.

14. If you graphed the data on the computer or calculator, use the graphing system to find an approximate equation for Computer Model 1 data. Why is this equation difficult to predict without graphing software?

15. Using Computer Model 1 data, estimate the track density for dust grains that originated from the following distances. If you have an equation for Computer Model 2, use it to estimate the track densities.

Distance	Computer Model 1	Computer Model 2
100 AU		

90 AU

80 AU

70 AU

60 AU

16. Besides travel time and initial distance from the sun, can you think of some other variables that might affect track density?

Bonus questions

17. In order to infer travel time from track density, scientists need to determine a track production rate, referred to as "track-rate estimate" in the *Science News* article. What is the track production rate and how is it expressed?

18. Scientists had previously estimated the track production rate at $6.5 \times 10^5/\text{cm}^2/\text{year}$. The new estimated rate is $4.4 \times 10^4/\text{cm}^2/\text{year}$. By what multiplicative factor are they different?

19. What would be the effect on the estimated travel time of the dust particles if one used the old track production rate instead of the new track production rate?

20. Based on the answers to question 3, we know that a dust grain's travel time appears to increase roughly like the square of the distance traveled. Use your answer from question 19 to approximate how much closer a grain's initial distance may have been to Earth, relative to what previous estimates would suggest.