Space dust may rain destruction on Earth

Some 30,000 metric tons of extraterrestrial dust fall to Earth each year, mixing unobtrusively with the home-grown grime collecting on all surfaces great and small. A new study suggests that the amount of space litter varies, occasionally flooding Earth's atmosphere with enough debris to trigger a prolonged crisis.

This week, as Hollywood dramatizes the instantaneous Armageddon brought on by a comet impact, two scientists look to extraterrestrial dust to explain extended bouts of extinctions. Stephen J. Kortenkamp of the Carnegie Institution of Washington (D.C.) and Stanley F. Dermott of the University of Florida in Gainesville describe their proposal in the May 8 SCIENCE.

The issue of how interplanetary dust affects Earth gained prominence after a pair of scientists hypothesized that waves of space particles triggered the last 10 ice ages (SN: 10/4/97, p. 220). That possibility was raised by Richard A. Muller of the University of California, Berkeley and Gordon J. MacDonald of the International Institute for Applied Systems Analysis in Laxenburg, Austria.

In Muller and MacDonald's model, the amount of dust reaching Earth rises and falls as the plane of Earth's orbit tilts up and down through the plane of the solar system. This orbital bobbing, they surmised, would cause the planet to pass through a thin band of dust every 100,000 years—a period that matches the ice age cycle. Every 100,000 years or so, the planet's temperature plummets, then rises in short thaws like the one that has graced the climate for the last 10,000 years.

Kortenkamp and Dermott tested this hypothesis by creating a model that computes the path of dust leaving the asteroid belt and falling toward the sun. Such debris accounts for perhaps three-quarters of the interplanetary dust that reaches Earth; the rest comes from comets, say the researchers.

The model calculations for the last 1.2 million years show that dust amounts do not vary with the tilt of Earth's orbit, a contradiction of Muller and MacDonald's proposal. Instead, say Kortenkamp and Dermott, the shape of the orbit alters dust accumulation.

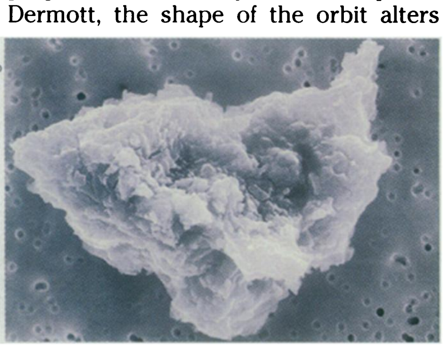
Over a period of 100,000 years, Earth's orbit gradually shifts from a nearly perfect circle to a slight oval and back again. In the circular orbit, the planet travels more slowly through the dust cloud and therefore sweeps up two to three times as much debris as it does in the oval orbit, according to the model. Kortenkamp compares this to a vacuum cleaner's picking up more dirt when pushed slowly over a carpet.

Records of extraterrestrial dust gleaned from seafloor sediments confirm the model results in part, says Kenneth A. Farley of the California Institute of Technology in Pasadena. Like the model, the sediments show dust increasing by a factor of 3 every 100,000 years. The problem lies in the timing. The sediments contain more dust when the model predicts that accumulations should be declining. "Something is really peculiar here," says Farley.

The answer may be that the model does not examine all of the asteroidal dust falling to Earth. Dermott is now studying the sizable fraction that gets caught temporarily in orbits just outside Earth and is later knocked loose.

Climate researchers are skeptical that a tripling of dust accumulation triggered the ice ages. Kortenkamp and Dermott leave that question aside but speculate that the amount of dust could rise to more than 300 times modern values following major collisions in the asteroid belt. Persisting for a million years or more, these dust storms could disrupt climate and bring about long periods of extinctions. Such collisions would also eject larger chunks, which could wallop Earth in the wake of the dust waves.

Farley remains skeptical, however, because sea sediment records going back to the days of the dinosaurs show no dramatic dust surges. "If such an event has occurred, it has not occurred in the last 65.5 million years." —*R. Monastersky*


Don Brownlee/Univ. of Washington

A 10-micrometer asteroidal dust particle collected by a high-flying airplane.

Basing transistors on lone carbon nanotubes

Using individual molecules as transistors promises to advance miniaturization strategy in the electronics and computer industries. Fabricating such tiny components, however, presents numerous challenges.

Now, researchers have shown that a microscopic tube of carbon atoms lying across a pair of metal electrodes can operate as a simple transistor at room temperature. Cees Dekker and his coworkers at the Delft University of Technology in the Netherlands describe their device in the May 7 NATURE.

The fabrication of this nanotube transistor represents "a new, important step towards molecular electronics," Dekker says.

Carbon nanotubes are cylindrical molecules about 1 nanometer in diameter and 1 to 100 micrometers long. They can be thought of as rolled-up sheets of carbon atoms arranged in a hexagonal network. Depending on the diameter of the tube and the alignment of the hexagonal pattern along the cylinder's axis, a nanotube can either conduct electricity like a metal or behave as a semiconductor.

The Delft team deposited carbon nanotubes onto arrays of prefabricated nanoelectrodes on the surface of a silicon dioxide layer covering a silicon base. The researchers then looked for semiconducting nanotubes lying across a pair of electrodes. By applying a voltage to the silicon base, they could switch such a nanotube from a conducting to a nonconducting state.

Because the device operates at room temperature, it meets an important requirement for potential practical applications, Dekker notes. Moreover, he adds, these nanotube transistors are generally quite robust, surviving a large number of experimental tests over a period of months.


Dekker et al.

False-color atomic force microscope image of a carbon nanotube (blue) lying in contact with two metal electrodes on a silicon base coated with a layer of silicon dioxide.

"Nanotubes have the advantage [over other unimolecular devices] of being much sturdier," says Robert M. Metzger of the University of Alabama in Tuscaloosa, who leads a group that developed a molecular rectifier (SN: 11/8/97, p. 293). However, subtle differences in the structure of individual nanotubes make it hard to predict a given nanotube's electronic properties.

Dekker and his coworkers are now trying to improve their control over the nanotube deposition process. They are also seeking ways to increase the transistor's output for a given input voltage.

"This is fascinating physics," Dekker says. Using single molecules as active electronic components, however, is a new research area, he warns. "Don't expect a molecular computer within a few years." —*I. Peterson*