Smithsonian

Spotlight on Science at the Smithsonian

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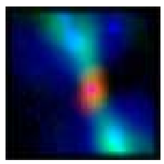

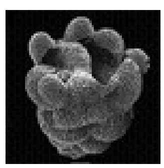

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- Dr. David Evans, Under Secretary for Science
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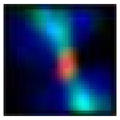
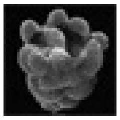


Measuring a Protoplanetary Disk

The Sun’s Magnetic Ropes

The Future of Tropical Forests



Planktonic Foraminifera Tell of Earth’s Past

Introduction from the Under Secretary for Science

In this installment of Spotlight on Science, we’ll look in space, tropical forests, and ancient oceans. First, researchers from the Smithsonian Astrophysical Observatory (SAO) are using the Submillimeter Array to probe the region around a young star. Their work is giving us a better understanding of the complex processes that govern the formation of stars and their protoplanetary disks. Continuing in space, SAO researchers are furthering the understanding of the “magnetic flux ropes” observed on our Sun. These ropes can pinch off and produce solar flares that can affect us here on Earth. Next, Smithsonian Tropical Research Institute scientists are examining the relationship between forest cover and population density. Their research suggests that global deforestation will decrease, regeneration of deforested areas will increase, and a mass extinction of rainforest species can be avoided. Finally, National Museum of Natural History researchers look to planktonic forminifera for information about the Earth’s climate in the Cretaceous Period. Fossils from these creatures provide evidence that the climate was far more variable than had previously been thought.

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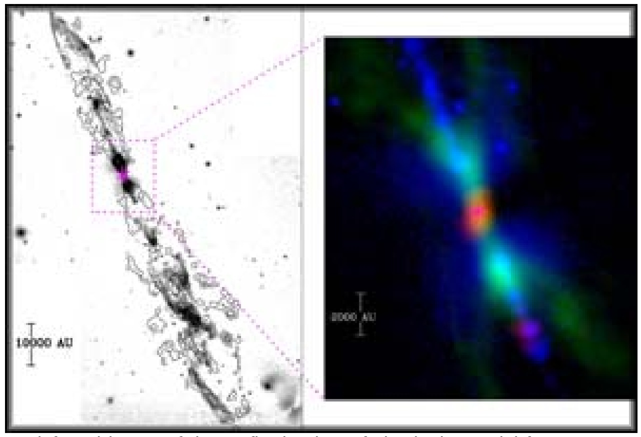

An infrared image of the outflowing jets of shocked material from a young star; contours show the distribution of dense gas around the star (not seen). SAO astronomers have used the Submillimeter Array to discover that a circumstellar protoplanetary disk located within the central contour is in its early stages of formation.

Measuring a Protoplanetary Disk

Reference

Chin-Fei Lee *et al*., "Infall and Outflow around the HH 212 Protostellar System," 2006, *The Astrophysical Journal*, 639, 292.

All stars form in roughly the same way, at least according to current thinking: gravitational forces coalesce the gas and dust in interstellar clouds until the material forms clumps dense enough to become stars. How this happens, however, is still very uncertain. The infall of matter is probably not symmetric, or it may be inhibited by the pressure of very hot radiation around the young stellar embryo, or perhaps constrained in other ways, all of which might enable some material to develop into disks around the stars which can in turn develop into planets. The differences in these arguments are important to our understanding of the formation of our Solar System because planets like the Earth are built from the material that does not make it into the star. One key issue is the timescale for the development of such a disk.

Writing in the *Astrophysical Journal*, a team of five Smithsonian Astrophysical Observatory (SAO) astronomers, Chin-Fei Lee, Paul Ho, Henrik Beuther, Tyler Bourke and Qizhou Zhang, and two colleagues, reports finding a young star which shows a dramatic outflow, but also shows infall associated with a small rotating disk of material. The team used SAO's Submillimeter Array (SMA) to probe a region a few thousand astronomical units (AU) in size around a star known to be ejecting matter in giant bi-polar jets. The astronomers discovered what they report as a dense core around the star with about 0.08 solar-masses of material. Inside the core is an edge-on disk of gas and dust whose mass is about twice as much, 0.15 solar-masses; this disk has an average radius of 460 AU, slowly rotates, and shows evidence for material infalling at a rate of about six millionths of a solar-mass per year. This rate of infall, the scientists calculate, suggests the disk should eventually stabilize with a size of about 75 AU in another 30,000 years. The observations imply that the disks can stabilize in a relatively short time, and that the team has caught this one at a very early stage in its development. The results also lend observational support to models in which stars and their protoplanetary disks form a complex combination of processes that can include both infall and outflow activity.

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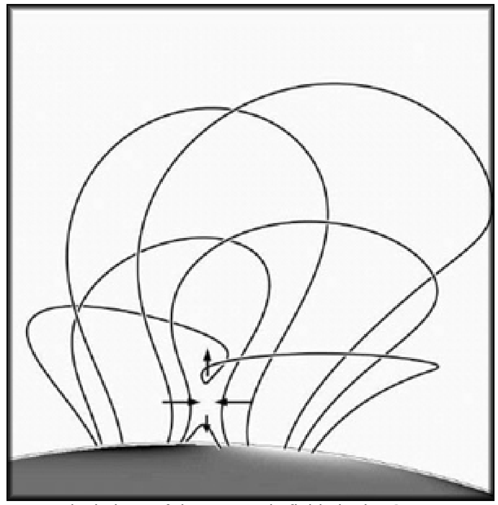

New calculations of the magnetic fields in the Sun's corona show that the fields can be twisted together into "ropes," shown in this figure as lines looping up from the solar surface and then back down again. The new results find that pressure from the fields can pinch the ropes near their base, shown in the diagram as pinching arrows, ultimately leading the magnetic ropes to spring free and eject streams of charged particles in a flare.

The Sun's Magnetic Ropes

The solar corona (the extended, gaseous, outer atmosphere of the Sun) is threaded by intense magnetic fields that extend upwards from the solar surface through the Sun's atmosphere. The corona is very hot, over a million Kelvin, and motions of this hot gas often cause the magnetic fields to twist into what are called "magnetic flux ropes." Astronomers believe that when these loop-shaped, twisted ropes snap, like taut rubber bands suddenly cut loose, they spring free and can power coronal eruptions and flares. Solar flares hurl gases and energetic, charged particles upwards with some going towards the Earth. These particle storms can disrupt communications, cause power line surges, and other destructive phenomena. Scientists have been working hard to better understand solar ropes and other possible coronal mechanisms.

Smithsonian Astrophysical Observatory astronomer Adriaan Van Ballegooijen and a colleague have extended their earlier models of solar magnetic fields to include some important but complex effects that restrict field twisting. They have also added in effects of the solar wind (the flux of charged particles ejected from the Sun's surface). One of the results of their new calculations is that these ropes will naturally pinch off and spring free. A second discovery is that when the ropes do snap, they do not completely dissipate, but leave enough magnetic field behind to induce long-term effects that aid in the production of subsequent flares. The scientists' paper marks the start of more detailed inquiries into the evolution of the solar corona, its flares, and the solar wind.

Reference

D. Mackay and A. A. van Ballegooijen, "Models of the Large-Scale Corona: I. Formation, Evolution, and Liftoff of Magnetic Flux Ropes," 2006, *The Astrophysical Journal*, 641, 577.

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Continued deforestation of tropical rainforests could lead to mass extinction of species.

The Future of Tropical Forests

Tropical rainforests are among the most species rich regions of the world. If current deforestation and habitat loss continues, a mass extinction of forest species is predicted in these areas. Smithsonian Tropical Research Institute scientist S. Joseph Wright and Helene Muller-Landau from the University of Minnesota have recently conducted a survey of human population trends and forest cover.

Wright and Muller-Landau use present-day relationships between forest cover and population density and United Nations population projections to predict future forest cover for tropical African, American and Asian countries. United Nations population projections generally predict that human population growth rates will decline and that urbanization will intensify. Wright and Muller-Landau predict future forest cover using both an optimistic scenario based on rural populations alone and a pessimistic scenario based on total (rural plus urban) populations. Continental trends suggest that deforestation will decrease and a larger area will remain forested in the Americas where population growth is slowing most rapidly and urbanization continues to increase. The outlook is not as optimistic in Asia and Africa. Asian forests are already quite diminished and populations are growing at a higher rate. In Africa, however, population growth overall and particularly in rural areas continues to increase, and net deforestation is expected to continue.

This research suggests that global deforestation will decrease, regeneration of forested areas will increase and a mass extinction of rainforest species can be avoided. Wright and Muller-Landau hope their research will stimulate more sophisticated predictions of future forest cover. In the meantime, further research is needed to establish the threat to individual species and determine which global, regional or local factors may influence these threats. This research will improve the ability to evaluate and manage human influences on forest species.

Reference

Wright, S. Joseph, and Muller-Landau, Helene C., "The Future of Tropical Forest Species", 2006, *Biotropica*, **38**(3), 287-301.

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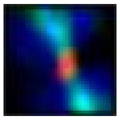

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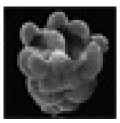
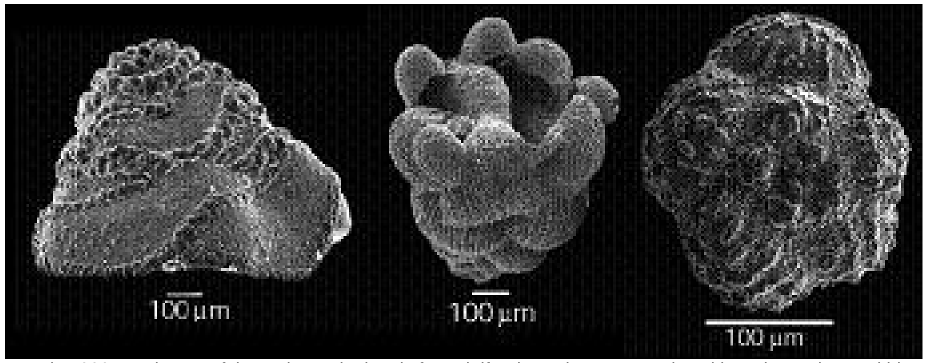


Planktonic Foraminifera Tell of Earth's Past

Reference

Isaza-Londoño C., K. G. MacLeod, B. T. Huber, Maastrichtian North Atlantic warming, increasing Stratification, and foraminiferal paleobiology at three timescales, 2006, *Paleoceanography*, 21, PA1012, Doi:10.1029/2004PA001130.



Nearly 1000 specimens of these three planktonic foraminiferal species were analyzed by Brian Huber and his coauthors in a study recently published in the journal *Paleoceanography.*

Planktonic Foraminifera Tell of Earth's Past

A recently published study in *Paleoceanography* by Museum of Natural History scientist Brian Huber and two colleagues from the University of Missouri reveals a high degree of climatic variability and regional differences separate from global temperature trends during the last 3 million years of the Cretaceous Period (68.5 to 65.5 Ma). These differences in temperature trends and high variability in ocean temperatures contrast with the previously held view that Cretaceous climates were stable and uniformly warm.

Planktonic foraminifera are single cell eukaryotes that live in the upper open ocean. They secrete a hard calcium carbonate shell that sinks to the seafloor after reproduction. Because of their diversity, abundance and wide distribution, fossils of planktonic foraminifera are useful in studying the environment in which they lived.

Results from nearly 1000 single specimen geochemical analyses of three planktonic foraminiferal species reveal consistent offsets in their oxygen and carbon isotope composition, providing evidence that they lived at different depths in the water and that the shallowest dwelling species probably hosted photosynthesizing algae in a symbiotic relationship. The oxygen isotope records for all three species indicates that the surface zone of the ocean at the subtropical site under study warmed by about 6ºC at a time when southern, high latitudes cooled by about 4ºC. Regional warming was accompanied by increased vertical stratification in the water column, probably resulting from intensification of the North Atlantic polar front. Thus, the site studied suggests regional subtropical warming at the same time as global cooling, contrasting with earlier views of uniform climatic change during the Cretaceous Period.

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