Physics News in 2001

A Supplement to APS News

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INTRODUCTION

Physics News in 2001, a summary of physics highlights for the past year, was compiled from items appearing in AIP's weekly newsletter *Physics News Update*. Many of the entries appearing here were also published in *Physics Today* magazine, where they were edited further by Stephen Benka. Readers should keep in mind that because of the way *Physics News Update* itself is prepared (short items aimed primarily, but not exclusively, at science journalists) and because of limited space in *Physics News in 2001*, some fields of physics research might be underrepresented in this compendium. Readers can get a much wider view of the year's worth of physics by going to the Physics News Update website at http://www.aip.org/physnews/update or APS's Physical Review Focus website at http://focus.aps.org/.

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ASTROPHYSICS

MAJOR NEW COSMIC MICROWAVE BACKGROUND MEASUREMENTS uphold the idea of an early "inflationary" era during which the observable universe expanded with superluminal speed and tiny quantum fluctuations in the density of matter were amplified into much larger structures. These structures are imprinted in the CMB as faint variations in the temperature across the microwave sky. The CMB, the curtain of photons set free when the expanding universe became cool enough to permit the existence of neutral atoms, is the earliest, largest, and furthest observable thing in all of science.

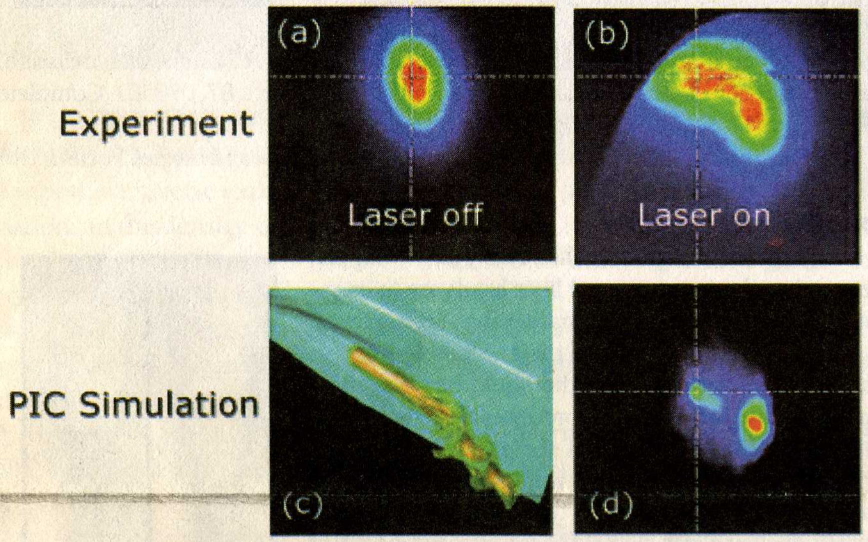
The best way to extract cosmological information from the CMB is to plot the observed microwave power as a function of the angular size of

peaks was the second great vindication. The third type of evidence, Turner said, would be the detection of gravity waves from before the time of the CMB.

IS ALPHA, LIKE PI, A FUNDAMENTAL CONSTANT, or does it change over time? Pi, the ratio of a circle's circumference to its diameter (pi can be defined in other ways too) doesn't seem to be changing, but alpha, the symbol for the fine structure constant, might be. Alpha is a measure of the intrinsic strength of the electromagnetic force and thus determines how strong an atom is bound and what kind of light is absorbed or emitted by the atom when an electron inside the atom moves from one internal quantum state to another. In

2001 meeting of the American Physical Society.

AN ELECTRON BEAM CAN BE REFRACTED at the interface between a plasma and a gas, much as light is refracted at an air water interface. A California based research collaboration (USC, UCLA, and Stanford) used a beam from SLAC's Final Focus Test Facility, consisting of 20 billion electrons at 28.5 GeV in a bunch that was about 0.7 mm long and 40 microns in radius. As the electron beam went along a long, thin "tube" of plasma, it first repelled plasma electrons, leaving the sluggish ions behind to form a positively charged channel, which focused the remaining electrons. As the beam left the plasma at a grazing incidence, the ion channel became asymmetric and the exiting beam was deflected by up to a milliradian. The researchers also showed that, at sufficiently small incident angles, the beam underwent total internal reflection. Thus, they envision magnet free particle storage rings or plasma based wires, although such "plasma waveguides" may require a laser to preform the ion channel. (P. Muggli *et al.*, *Nature* **411**, 43, 2001.)

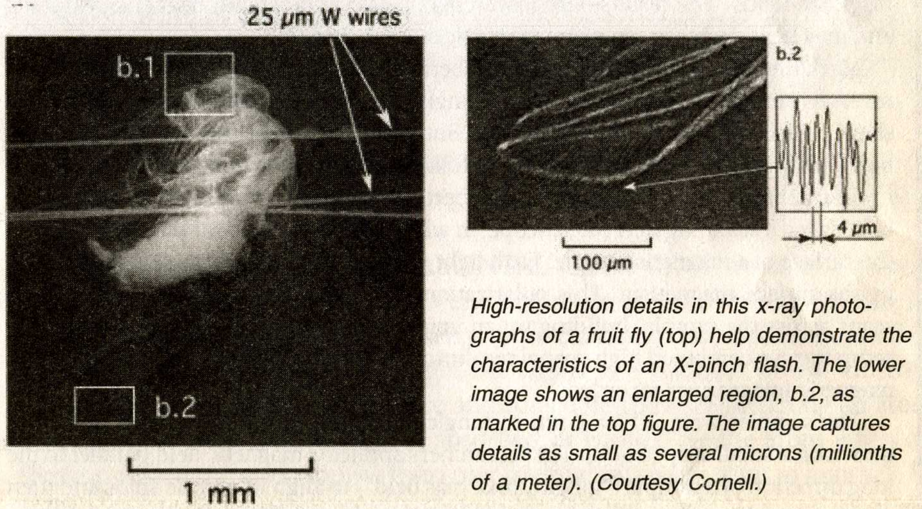


Experimental (a-b) and simulated (c-d) images show a plasma, a million times less dense than air, refracting a portion of a charged-particle beam. Turning on a laser creates the plasma. In image c, the plasma is shown in blue, and the beam in gold. (Courtesy USC).

THE NUCLEAR LIGHTHOUSE EFFECT has been applied to samarium 149. The NLE technique was developed last year by researchers from the University of Rostock in Germany. It allows physicists to get very accurate lifetime measurements of certain short lived nuclear resonances. In their recent work, the Rostock scientists mounted a thin sheet of samarium oxide on the inside wall of a small cylinder. They then placed the cylinder in an x ray beam at the Advanced Photon Source at Argonne National Laboratory and spun it at 15 kHz with jets of pressurized air. The nonresonant x rays went straight through

distance scale for the interaction at the crossover energy is about 0.1 fm, larger than many current theoretical expectations for the onset of quark counting rule behavior. (E.C. Schulte *et al.*, *Phys. Rev. Lett.* **87**, 102302, 2001.)

X PINCH FLASH PHOTOGRAPHY. A metal wire is heated when a current runs through it. A 25 micron thick molybdenum wire carrying 105 amps is vaporized into a plasma, and the magnetic field generated by the current compresses that plasma. Cross two such wires and at their juncture you get an x pinch, a 1 to 2 micron region of 10^7°C plasma that emits greater than 2.5 keV x rays for less than a nanosecond. Now, researchers at Cornell University's Laboratory of Plasma Studies have used such x ray point sources to generate few micron resolution radiographs of tiny objects such as the housefly and its wing, using phase contrast imaging. For more on the imaging technique, see *Physics Today*, July 2000, page 23. Several x pinch results were presented in November 2001 at the American Physical Society's Division of Plasma Physics meeting. (Papers RP1.101-104 and UI2.001)



High-resolution details in this x-ray photographs of a fruit fly (top) help demonstrate the characteristics of an X-pinch flash. The lower image shows an enlarged region, b.2, as marked in the top figure. The image captures details as small as several microns (millionths of a meter). (Courtesy Cornell.)

OTHER PHYSICS FIELDS

DRIPPING FROM FAUCETS AND CEILINGS. Understanding dripping better can improve inkjet printing and deposition of DNA onto gene chips, among other things. Purdue researchers solved the fundamental Navier Stokes equations for a single drop from a faucet, then observed dripping with a fast camera to develop a model for simulating sequences of hundreds of drops. Among the team's observations was "period doubling," in which drops can fall at two characteristic intervals (such as 4 s followed by 2 s). Meanwhile, University of Texas researchers have shown how to prevent drips from a ceiling for up to weeks at a time. They found that a vertical heat gradient in the gas