Physical Sciences

The smoothness of the universe

The ordinary simple theory of the beginning of the universe predicts a very uniform smooth distribution of matter at the start. To provide for galaxies, however, it may be necessary to amend the simple theory and say that tiny fluctuations in the density of matter were present from the very beginning.

In the microwave background radiation that pervades the universe and has the spectrum of a blackbody at a temperature of 2.7 kelvin, observers have a probe. Evidence of such density fluctuations would show up as small scale fluctuations in the temperature of the blackbody. Juan M. Uson and David T. Wilkinson of Princeton University in Princeton, N.J., used the 43-meter radio telescope of the National Radio Astronomy Observatory (NRAO) in Green Bank, W.Va., to search for fluctuations on the scale of 4.5 minutes of arc on the sky. They looked in 12 fields around the sky near the north pole. In the Feb. 1 ASTROPHYSICAL JOURNAL LETTERS, they report with 95 percent statistical confidence that there can be no fluctuations greater than 4.5 parts in 100,000 on that scale.

The Very Large Array of radio telescopes near Socorro, N.M., in a configuration simulating a single antenna 700 meters across, enabled E.B. Fomalont of NRAO in Socorro, K.I. Kellerman of NRAO in Green Bank and J.V. Wall of the Royal Greenwich Observatory in Herstmonceux, England, to search for fluctuations on scales of tens of second of arc. The total field that this group observed was 10 minutes of arc in diameter. They report in the Feb. 15 ASTROPHYSICAL JOURNAL LETTERS that, also at a 95 percent confidence level, there are no fluctuations greater than 0.10 percent on a scale of 18 seconds, 0.08 percent on a scale of 30 seconds and 0.05 percent on a scale of 60 seconds. Maybe theory will have to be amended some other way.

The cometary icebox

Astronomers have long believed that water ice is present in comets. Now for the first time there may be direct evidence for ice in the coma of a comet.

In the Feb. 15 ASTROPHYSICAL JOURNAL LETTERS Martha S. Hanner of the Jet Propulsion Laboratory, part of the California Institute of Technology in Pasadena, reports that the discovery on July 19, 1983, of comet Cernis 19831 gave a favorable opportunity to look for ice. This is because Cernis was found at perihelion at a distance from the sun of 3.32 times the radius of the earth's orbit. To look for ice a comet must be visible at distances like that; nearer the sun, the ice is expected to dissipate.

In the light reflected by Cernis's coma, Hanner found an absorption feature at a wavelength of 2.9 to 3.0 micrometers that she attributes to water ice.

Lamb shift in muonium

The Lamb shift is a small change in the energy of a certain state of hydrogen or hydrogen-like atoms. Measuring it can test the accuracy of calculations in quantum electrodynamics, the theory of electrical behavior in particle physics, a question of central importance in the science.

Recent measurements in hydrogen have shown some discrepancies from theory. The discrepancy may be due to internal structure in the proton or to a flaw in the theory. To decide, experimenters have recourse to muonium, a quasiatom in which an electron orbits a muon. The muon is not supposed to have internal structure.

Making muonium is not easy, but two experiments reported in the March 12 PHYSICAL REVIEW LETTERS (by A. Badertscher of Yale University et. al. and by C.J. Oram of the TRIUMF laboratory in Vancouver, Canada, et. al.) have made muonium and seen the Lamb shift in it. Oram et. al. have also measured its energy, but not yet precisely enough to answer the question.

Energy

Biomass: Roam on the range

Some day mobile harvesting units may roam the arid chaparral of southwestern United States. These machines would cut down the dense tangle of scrubby trees and brush found in these areas, grind them into sawdust and process the material into high-quality diesel fuel. In the Feb. 23 NATURE, James L. Kuester of Arizona State University in Tempe, Edwin A. Davis of the U.S. Forest Service laboratory in Tempe and Marvin O. Bagby of the U.S. Department of Agriculture research center in Peoria, Ill., look at the feasibility of such a scheme. They conclude that "relatively unproductive chaparral and woodlands are a valuable resource from which high-grade liquid fuels can be produced."

Kuester, a chemical engineer, says the biomass conversion process, indirect liquefaction, now being used involves two steps. First the feedstock (for example, plant material), is converted to "synthesis gas," a mixture of carbon monoxide, hydrogen, methane, carbon dioxide and olefins like ethylene. This gas mixture is exposed to a catalyst that aids in the formation of a high-quality product similar to diesel fuel. The process yields about 40 to 50 gallons of liquid fuel for every ton of feedstock. "The yields will vary," Kuester says, "depending on what the synthesis-gas potential of the various feedstocks is, but within broad limits they react the same."

The chief problem is that the cost of biomass conversion is very sensitive to how far feedstocks have to be moved. "You can't afford to move the stuff very far," says Kuester. The answer is to put the processing unit near the biomass source. However, at the current stage of development, conversion units large enough to be economically attractive are too big to move around easily. "Our work is aimed at getting these things small enough to be portable," says Kuester.

People from all over the world have already shown interest in the research. "All kinds of industries have all kinds of trash that they'd like to do something with," says Kuester. This includes materials like coconut shells, fir bark and cotton wastes. The U.S. Forest Service is interested because to increase water flow into reservoirs, augment forage for grazing, improve deer habitat and reduce the spread of wildfires, it often must control brush by controlled burning or chemical treatment. If the brush instead could be harvested, leaving root systems intact so that plants can regrow, and converted to a high-quality fuel, says Davis, then a potentially valuable energy resource would not be sacrificed.

Striking oil in the laboratory

For six years, two Australian researchers patiently watched over a set of 1-gram samples of organic material sealed inside stainless steel "bombs." The samples were derived from brown coal and a type of oil shale called torbanite. Each week, the temperature of the samples was increased by 1°C, gradually heating the material from 100°C to 400°C. By the time the experiment ended, the scientists had struck oil and gas. In the March 8 NATURE, J.D. Saxby and K.W. Riley of the fossil fuels division in CSIRO, an Australian government research organization, report, "We believe the present experiments, which are possibly as slow as can be realistically planned within a human time scale, have for the first time successfully duplicated hydrocarbon generation in a continuously subsiding sedimentary basin."

The researchers found that after four years a product "indistinguishable from a paraffinic crude oil" was generated from the torbanite-derived samples, while brown coal produced a "wet natural gas." They write, "The products of these slow, 'molecule-by-molecule,' solid-state decompositions are all typical of natural gases and petroleum, with no olefins or carbon monoxide being formed." The results shed light on the much-debated question of the origins of crude oil and natural gas by showing that slow chemical processes, under the right conditions, can generate hydrocarbons like those found naturally.