

Kobzarev and Lev Okun in Russia, and by Tom Kibble of London's Imperial College, is that the initial phase transition in the proto-Universe could have contained defects - tiny regions of space trapped in the 'old' high energy phase. These defects could have gone their own way, developing into separate structures which helped to seed the subsequent evolution of galaxies into clusters and sheet-like 'superclusters'.

When this happened just 10^{-34} second after the Big Bang, the energy densities were out of reach of anything that can ever be recreated directly on Earth, and scientists, for whom ingenuity is an everyday tool, have to be especially resourceful.

In 1985 W.H. Zurek of Los Alamos suggested experiments to look for signs of such defects in model systems, for example the delicate phase transitions of superfluid helium-4 transforming into a normal fluid at about 2K. In this way laboratory studies could be used as models for the infant Universe.

Subsequent experiments saw suggestions for such defects in another delicate system, the rod-like molecules of liquid crystals. Now a British group (Lancaster/Exeter) has seen signs in a liquid helium-4 system. With a sample of highly pure (possibly perfect) helium-4, the team hoped to avoid problems with defects from nucleation around impurities.

One problem with such cryogenic experiments is that any defects are not easy to spot. The trick is to detect them through the attenuation of sound waves across the 4-millimetre space of the experiment. The observed strong attenuation suggests the creation of an excess of vortex-type activity, difficult to explain by hydrodynamics alone.

These defects induced by phase

transitions are possible analogues of cosmic seeds.

P.C. Hendry et al, Nature, Vol. 368, p. 315 (24 March 1994)

Bookshelf

Neutrino Interactions with Electrons and Protons - Edited by Alfred K. Mann, published by the American Institute of Physics (ISBN 1-56396-228-4)

Subtitled 'an account of an Experimental Program in Particle Physics in the 1980s', this book is a collection of 13 reprinted papers presenting experimental results from experiment E-734 originally proposed in 1978 to measure the elastic scattering of neutrinos and antineutrinos from electrons and protons using the neutrino beam at the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory.

This experiment took data during the 1980s and the apparatus was dismantled in 1990. Its main results cover measurements of the weak mixing angle, and some measurements which were not in the original proposal, such as limits on the electromagnetic properties of the muon neutrino and on the mixing between electron- and muon-neutrinos. The collaboration, with 35 physicists participating, included Osaka and KEK and was the earliest formal collaboration in high energy physics between American and Japanese institutions.

This book gives only a very partial account of neutrino physics in the 1980s. Because of the relatively low neutrino energy of only few GeV, E-734 physics did not include the study of deep inelastic scattering which has

greatly contributed to the understanding of the nucleon structure in terms of quarks, antiquarks and gluons. Furthermore, because of the low event rate at the low neutrino energy, most of the E-734 results have been superseded by the more precise results obtained by higher energy neutrino experiments at CERN and Fermilab, however with the exceptions of the limits on neutrino mixing and of the measurement of the neutral current cross-section for neutrino and antineutrino elastic scattering. It is not clear to me why the American Institute of Physics has chosen to publish this book in a series 'Key Papers in Physics'.

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