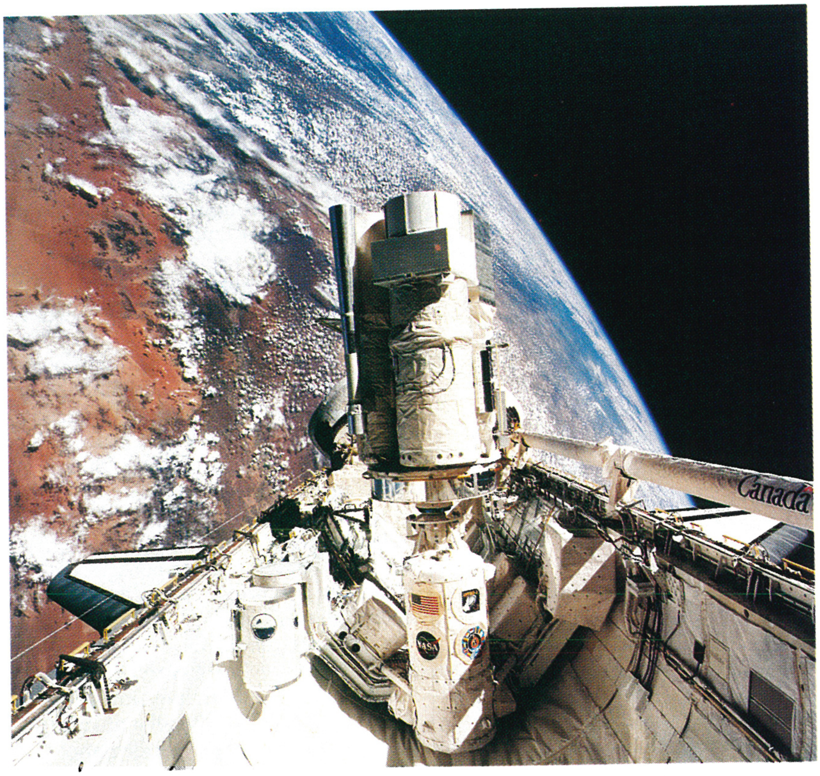

THE HOPKINS ULTRAVIOLET TELESCOPE was part of the Astro-2 Observatory, shown here in the payload bay of the space shuttle Endeavour. HUT viewed the spectra of quasars well into the ultraviolet and provided high-quality evidence of primordial helium. (Courtesy of Johns Hopkins University.)

sity of hydrogen.

The density distribution of Lyman-alpha forest clouds comes from the extensive measurements of hydrogen absorption spectra done with Earth-bound telescopes. Such hydrogen spectra are far more finely resolved than the helium measurements made from space, because optical telescopes have much larger collecting areas. Until recently, none of these optical telescopes had seen Lyman-alpha forest clouds with hydrogen column densities below 5×10^{13} per square centimeter. But this year Antoinette Songaila, Esther M. Hu and Lennox Cowie at the University of Hawaii at Manoa, in Honolulu, used the Keck 10-meter optical telescope to extend[3] that lower limit down to 2×10^{12} cm^{-2}.

The Hawaii group finds that it can account for all the absorption seen in the Hubble measurements by including helium in the very low-column-density clouds and making certain assumptions, without requiring additional helium in the diffuse intergalactic medium. These results jibe with theoretical predictions of Michael Shull, Mark Giroux and Mark Fardal of the Joint Institute for Laboratory Astrophysics and the University of Colorado,[4] in Boulder, and by Piero Madau of the Space Telescope Science Institute and Avery Meiksin of the University of Chicago. Shull and his colleagues have recently reached a similar conclusion for the optical depth seen by HUT.

Davidsen and his colleagues have chosen to make a cutoff at a column density of 10^{13} cm^{-2}, contending that clouds with densities below that value are virtually indistinguishable from an inhomogeneous intergalactic medium. They have calculated that helium in the clouds below that cutoff accounts for about two-thirds of the total absorption. (All these calculations depend on assumptions such as the spectral distribution of ionizing radiation.)

Distinguishing between a diffuse intergalactic medium and clouds, as the column density gets ever smaller, becomes almost a semantic question. However, the answer is of importance to cosmologists concerned with the formation of structure in the universe. Measuring the difference poses quite a challenge, requiring improvements in both resolution and collecting area. At least a tenfold improvement in resolution is promised from the Far Ultraviolet Spectroscopic Explorer satellite, scheduled for launching in 1998 by NASA, with participation by the Canadian Space Agency and France's National Center of Space Studies.

One ultimate goal of all these measurements is to estimate the contribution of the primordial gases to the mass of the universe. Even if one could clearly distinguish how much absorption came from gases in clouds as opposed to those in relatively smooth intergalactic regions, it is difficult to make a quantitative estimate of the total mass of hydrogen and helium. Among the factors one has to estimate are the ionization fractions of hydrogen and helium, which depend on the intensity and spectral shape of the diffuse ultraviolet radiation field at high z.

Present estimates already indicate the existence of far more matter in the intergalactic clouds than in the stars. Jeremiah Ostriker of Princeton told PHYSICS TODAY that better measurements will tell us if the total intergalactic medium is cosmologically significant or, as expected, still far below the cherished value needed for closure.

BARBARA GOSS LEVI

References

1. P. Jakobsen, A. Boksenberg, J. M. Deharveng, P. Greenfield, R. Jedrzejewski, F. Paresce, Nature **370**, 35 (1994).
2. D. Tytler, X.-M. Fan, S. Burles, L. Cottrell, C. Davis, D. Kirkman, L. Zuo, to be published in QSO Absorption Lines, Proc. ESO Workshop, Munich, 1995, J. Bergeron, G. Meylan, J. Wampler, eds., Springer-Verlag, Heidelberg, Germany (1995).
3. A. Songaila, E. M. Hu, L. L. Cowie, Nature **375**, 124 (1995).
4. M. Giroux, M. Fardal, J. M. Shull, Astrophys. J. **451**, 477 (1995).

German Neutron Source Gets Go-Ahead

Neutron scattering research in Germany should get a boost from the construction of a new research reactor, called the FRM-2, at the Technical University of Munich. The German federal government and the state of Bavaria have approved funding for the reactor, which, together with the beam hall and instruments, is expected to cost DM720 million. Although the reactor will have only about one-third the power of the 57-megawatt facility at the Institut Laue–Langevin in Grenoble, France—the research reactor with the highest neutron flux—the FRM-2 will have somewhat over half its flux (8×10^{14} neutrons per square centimeter per second compared to 1.5×10^{15} cm^{-2} s^{-1} at the ILL). With a capacity for 30–35 instruments, the reactor will provide additional neutron capability at a time when beam lines at ILL and other reactors are heavily oversubscribed. FRM-2 will have a cold source to provide neutrons whose temperatures are below 60 K; the flux of these cold neutrons will be comparable to that at the ILL. A unique feature of the FRM-2 will be a built-in facility for treating human cancer with fission neutrons. The chief designer of the FRM-2 is Klaus Böning of the Technical University of Munich.

The reactor has not been without controversy. To squeeze as much flux as possible out of the 20-MW reactor with maximum safety and at a moderate price, the designers plan to fuel the core with uranium enriched to more than 90 percent in the fissionable isotope ^{235}U, material that can be used for nuclear weapons. Concern over the proliferation aspects of such fuel prompted the designers of the Advanced Neutron Source at Oak Ridge National Laboratory, which would have provided five times the flux of the ILL, to consider modifications in which higher performance would be traded for lower levels of enrichment (see PHYSICS TODAY, November 1994, page 17). But earlier this year the ANS, which was expected to cost $2.9 billion, lost its bid for construction funding.

The FRM-2 design runs counter to a US-sponsored program—the Reduced Enrichment for Research and Test Reactors Program—to convert many research reactors around the world now fueled by highly enriched uranium to low-enriched uranium (technically, uranium enriched to less than 20% in ^{235}U). The US Department of Energy has been ready to assist the Germans in redesigning the FRM-2 to use low-enriched fuel. However, Böning contends that there is no known fuel one might substitute in the reactor's compact core without unacceptable consequences for its performance and long delays for a redesign. Winfried Petry of Munich's Technical University, a designated member of the FRM-2 steering committee, points out, for example, that the International Nuclear Fuel Cycle Evaluation conference, which ended in 1980 and paved the way to the RERTR initiative, acknowledged that "there are specific applications requiring high flux reactor operation that can only be met with high enriched fuel."[1]

BARBARA GOSS LEVI

Reference

1. "Report of the INFCE Working Group 8," International Atomic Energy Agency, Vienna, Austria, 1980. ■