undoubtedly significant He component in both clouds is not seen at optical frequencies because all its excitations remain in the UV even at these high redshifts.

"It's quite possible that the first generation of stars produced nothing heavier than oxygen," says Santa Cruz theorist Stan Woosley. "So I'm particularly impressed by the lack of carbon and oxygen."

Fumagalli and coworkers place an upper limit of $10^{-4.2}\,Z_\odot$ on the metallicity of cloud A. The other apparently metal-free cloud, found by the team in a different LLS, has only about 15% of cloud A's column density. So its upper metallicity limit, $10^{-3.8}\,Z_\odot$, is somewhat weaker.

Though each cloud, perhaps 100 light-years thick, was several orders of magnitude denser than the cosmic mean of 10^{-5} H atoms per cm^3 in that epoch, neither is thought to have been dense enough to form late first-generation stars. "But they may well be our first sighting of the so-called cool flows predicted by computer simulations of that epoch," says Prochaska. Those would be filamentary intergalactic streams of moderately dense, low-metallicity gas that flow into galactic halos and replenish the gas that sustains star formation.[2]

The primordial isotope ratio

The primordial D/H abundance ratio is particularly important to cosmologists because its predicted value depends sensitively on the cosmic mean baryon density. That density, usually given as Ω_b, the fraction of all mass and energy attributed to ordinary baryonic matter, is determined from cosmic-microwave-background (CMB) measurements to be $(4.5 \pm 0.1)\%$. (See PHYSICS TODAY, April 2003, page 21.) That predicts a D/H ratio of $10^{-4.6}$.

Stars can destroy D. So a long-standing question had been whether direct measurements of D/H in high-z clouds with small but nonzero metallicity reliably represent the primordial ratio. Figure 2 compares the CMB prediction with a variety of measurements at different metallicities, including the new measurement in LLS1134. They are all seen to be consistent, with no trend attributable to stellar destruction.

"So we can now conclude," says Fumagalli, "that deuterium abundances from quasar absorption-line systems are solid anchor points for models of galactic chemical evolution."

Bertram Schwarzschild

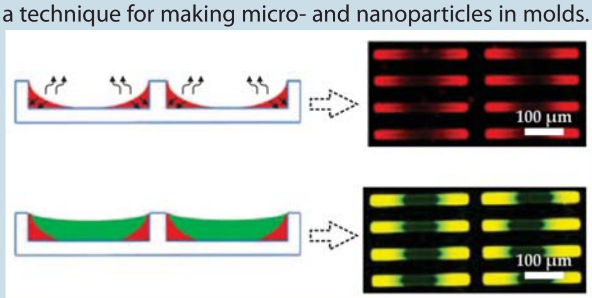
References

1. M. Fumagalli, J. M. O'Meara, J. X. Prochaska, *Science* **334**, 1245 (2011).
2. A. Dekel et al., *Nature* **457**, 451 (2009).

physics update

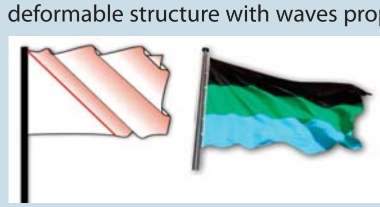
These items, with supplementary material, first appeared at http://www.physicstoday.org.

Molding many-faced particles. Scalable production of micron- and nanometer-sized particles with controlled sizes, shapes, and compositions is of interest for a host of applications. Toward that end, in 2005 Joseph DeSimone and colleagues (University of North Carolina, Chapel Hill) introduced PRINT—particle replication in nonwetting templates—a technique for making micro- and nanoparticles in molds.



The researchers fill an array of molds with an organic monomer liquid, use UV light to cure the liquid into a polymeric solid, extract the polymer particles using an adhesive film, and free them by dissolving the adhesive. In addition to pursuing various biomedical applications, DeSimone and colleagues have used PRINT to produce Janus particles: Hydrophobic on one side and hydrophilic on the other, the particles are interesting for the self-assembled structures they form (see the Quick Study by Steve Granick, Shan Jiang, and Qian Chen in PHYSICS TODAY, July 2009, page 68). The researchers fill the molds with a dilute solution of a hydrophilic monomer, evaporate off the solvent, and top off the molds with a hydrophobic monomer. Now, they've exploited capillary forces in rod-shaped molds to produce a wider range of multiphase particles. As shown in the figure, when the molds are filled with a hydrophilic solution and the solvent evaporated, the remaining liquid is drawn to the molds' ends; topping off with a hydrophobic monomer gives symmetric triblock particles. The researchers also created asymmetric triblock and diblock rods by spinning the partially filled molds in a centrifuge to drive some or all of the hydrophilic liquid to one end. (J.-Y. Wang et al., *J. Am. Chem. Soc.*, in press, doi:10.1021/ja2066187.) —JLM

Wrinkled roaches and flapping flags. For fluid dynamicists who seek a greater understanding of fluid–solid interactions, a flapping flag is a simple realization of a deformable structure with waves propagating in the direction of fluid flow. From models of such systems, researchers have determined, for example, that stiffer flags stretch nearly flat as they fly, as do those subjected to high fluid drag, whereas heavier flags form more and larger-amplitude wrinkles. Now, Jérôme Hœpffner at the Pierre and Marie Curie University in Paris and Yoshitsugu Naka at the University of Lille in France explain why the flag's wrinkles are oblique and how those oblique waves counterbalance gravitational forces. The researchers divide a flapping flag into two parts, as seen in the schematic and image: the pinned portion, represented by a right triangle, and the unpinned portion, which they call the roach, a term used for extra material on a sail. As the roach begins to collapse under its weight, it forms oblique waves, an observation that had not been explained by prior models. The researchers find that the flag's lift comes primarily from those waves. Aerodynamic forces act orthogonal to the wave-crests and impart the periodic rolling and snapping of the upper unpinned corner, which has been shown in old flags to suffer the greatest wear. (J. Hœpffner, Y. Naka, *Phys. Rev. Lett.* **107**, 194502, 2011.) —JNAM



Measuring morphological change. Objects alter their form in the course of such physical and biological processes as sedimentation and species differentiation. One