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A Bubble Chamber Revival: Superheated Liquid Detectors for Dark Matter Searches and Other Applications

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Bubble chambers were recently deemed to be obsolete, of interest only to historians, but a few new applications have unexpectedly emerged in nuclear and particle astrophysics. These include the search for WIMP dark matter and the measurement of a few otherwise intractable nuclear cross sections. The new bubble chambers exploit features of the bubble nucleation process that were unappreciated or irrelevant in the 1950s-1970s when the technology was known for its capability to provide fine-grained tracking of high energy particles in a dense target medium. By carefully tuning the temperature and pressure, a liquid can be made selectively sensitive to particles on the basis of their specific rate of energy loss, enabling a high degree of background rejection power when searching for rare heavily-ionizing tracks. Surprisingly, additional information on the microstructure of particle tracks can be extracted from the acoustic noise produced by bubble nucleation. Other novel features of the new bubble chambers include the use of digital photography, self-triggering, and the achievement of nearly continuous sensitivity by the avoidance of bubble nucleation on internal wetted surfaces.