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A glimpse into the cosmic horizon problem: measuring topological defects in a supersonically expanding toroidal Bose-Einstein condensate AVINASH KUMAR, STEPHEN ECKEL, IAN SPIELMAN, GRETCHEN CAMPBELL, Joint Quantum Institute, University of Maryland and NIST — In standard (non-inflationary) cosmology, the expansion of the early universe occurs at a speed larger than the speed of light. This expansion produces a horizon problem: the expansion causes initially near-by points to separate at a velocity larger than that of light and become causally disconnected. We mimic this horizon problem in an ultracold atomic experiment by creating a sonic analog of the expansion of the early universe. Our experiment consists of neutral ^{23}Na atoms trapped in an all optical ring that expands at supersonic speed. Because information can propagate only at the speed of sound, a supersonic expansion creates causally disconnected regions, whose phase evolve at different rates. After the expansion ends, these regions of different phase recombine, giving rise to spontaneous non-zero winding numbers when integrated around the whole ring in a manner similar to that envisioned by Kibble and Zurek. We measure the resulting winding number distribution as a function of initial radius, final radius, expansion time and sound speeds. We compare to a theory that connects the geometry and speed of expansion to the number of causally disconnected regions, finding good agreement with the winding number distribution predicted according to the geodesic rule.

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