Los Alamos analyzes meteor fragments nondestructively

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Laboratory researchers and collaborators used the Los Alamos Neutron Science Center (LANSCE) User Facility to perform novel compositional tomography characterizing small samples of the Chelyabinsk meteor, the largest fireball to strike Earth in 100 years. The team employed LANSCE's combination of proton and neutron radiography and neutron diffraction tools to gain deeper insights into the meteorite's physical structure, chemical composition and microstructure without making a single slice. Conventional analytical approaches would destroy valuable details.

Significance of the research

The nondestructive method aims to preserve spatial relationships of components and provide three-dimensional compositional information. The distribution of elements, the minerals present in the fragments, as well as their microstructure (preferred orientation, defects, grain sizes, etc.), aid researchers in interpreting the meteorite's origin and history. The Chelyabinsk meteorite is a low iron, low metals chondrite (stony meteorite). Therefore, it potentially could reveal information about the early solar system. The Laboratory combined technique of neutron and proton radiography has potential advantages of inferring some compositional information from the resonance absorption of neutrons and could possibly examine larger samples.

Understanding the structure of these bolide-event meteorites might be useful in developing effective mitigation strategies for deflecting much larger meteoroids that could otherwise result in mass extinction events.

Research achievements

The team employed a range of LANSCE probes to analyze Chelyabinsk fragments and two pieces of Australia's 1969 Murchison meteorite. To study fragments the size of playing die, the researchers performed neutron crystallography using the HIPPO (high-pressure/preferred orientation) instrument, tomographic proton radiography (invented at Los Alamos) and neutron time-of-flight radiography. Neutron diffraction adds the ability to confirm mineral composition and potential preferred orientation or texture. Characterization of texture may enable detection of localized melt or deformation textures from collisional shock events.

The researchers preliminarily identified at least one specific mineral phase as kamacite (a nickel-iron alloy) through neutron absorption of the isotope cobalt-59. This identification of specific isotopes through neutron absorption shows the potential of extending tomography measurements to compositional tomography. Identification of specific mineral phases may provide internal density standards, which would improve the quality of information on tomographic reconstruction.

The Proton Radiography facility made 721 images of the Chelyabinsk meteorite sample, resulting in a 360-degree radiographic view of the sample. Individual constituent grains and fissures are readily identifiable as the image rotates.

The team

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