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Technische Universität München

Press Release

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Ultrasound tomography reveals damage zones underneath meteor craters

Close-up on impact craters

Meteorites create more of an impact than the visible crater on the surface of the earth. Cracks and fissures occur underneath the impact site, too, and vary according to the size, power and impact angle of the celestial body. Up to now, geophysicists have not been able to accurately measure the true extent of these damage sites. Scientists from Technische Universität München (TUM) are currently trying to gain a better understanding of how craters are formed. Their work involves smashing miniature meteorites into rock under laboratory conditions – and then analyzing the craters using ultrasound tomography.

The metal spheres which the researchers aim at a block of sandstone travel at a velocity of up to 30,000 kilometers per hour. These miniature meteorites simulate the destructive power of their celestial counterparts in the laboratory of the Fraunhofer Institute for High-Speed Dynamics in Freiburg. Projectiles, which have a diameter of one centimeter, leave a crater six centimeters wide and one centimeter deep in the sandstone. Using ultrasound tomography, scientists from TUM have discovered that the impact creates much more widespread damage than can be seen with the naked eye or even under a microscope. Underneath the crater, a damage zone forms that is up to eight times wider than the crater itself.

Recreating cosmic forces in the lab

“With natural craters, we often have to guess as to the extent of the shock-induced damage and the level of fracturing attributable to subsequent weathering of the rock,” says Prof. Christian Grosse from TUM’s Chair of Non-destructive Testing. Now, using ultrasound analysis, scientists can systematically determine how the size, power and impact angle of a meteorite affect the damage zone underneath the crater. “With vertical impact, for example, we have noticed that the damage zone is hemispherical in shape. But if the meteorite hit the earth at an oblique angle, the damage zone could look completely different,” remarks Grosse.

In collaboration with geoscientists, physicists and engineers, Prof. Grosse is trying to gain a better understanding of how meteorite craters are formed. “Collisions involving celestial bodies played a hugely important role in the creation of our galaxy. With these crater experiments, we can gain a clearer picture of their impact on our own planet.”

Signals from the rock’s core

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Using ultrasound tomography means that the degree and extent of the hidden cracks in the rock can be measured without damaging the valuable experimental craters. This non-destructive method involves sending an acoustic signal in a particular frequency through the block of sandstone. Since the sound waves travel through rock at 3,000 meters per second – around ten times faster than through air – cracks and fissures produce signals with a greater amplitude.

The scientists then uses these signals to create velocity fields which show where the sound waves were stalled by cracks. “In the next phase, we will change the release energy and the impact angle of the miniature meteorites – which will create different damage zones underneath the craters,” explains Grosse.

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About the project:

The research unit MEMIN (Multidisciplinary Experimental and Modeling Impact Crater Research Network) financed by the German Research Foundation (DFG) is aimed at understanding the dynamics of hypervelocity impact processes and the formation of meteorite craters by means of experimental and numerical techniques.
MEMIN is delocalized; participating institutes are currently the Museum für Naturkunde Berlin, the Fraunhofer Institut für Kurzzeitdynamik Freiburg, Universität Freiburg, GeoforschungsZentrum Potsdam, Technische Universität München, Universität Münster and University of California at Berkeley. The project started in 2009 and is now funded for three more years.

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Technische Universität München (TUM) is one of Europe’s leading research universities, with around 500 professors, 10,000 academic and non-academic staff, and 35,000 students. Its focus areas are the engineering sciences, natural sciences, life sciences and medicine, reinforced by schools of management and education. TUM acts as an entrepreneurial university that promotes talents and creates value for society. In that it profits from having strong partners in science and industry. It is represented worldwide with a campus in Singapore as well as offices in Beijing, Brussels, Cairo, Mumbai, and São Paulo. Nobel Prize winners and inventors such as Rudolf Diesel and Carl von Linde have done research at TUM. In 2006 and 2012 it won recognition as a German "Excellence University." In international rankings, it regularly places among the best universities in Germany. www.tum.de

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