Researchers find number of cracks in struck glass related to speed of projectile

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(Phys.org) —A team of researchers from Aix-Marseille University in France has found that the number of cracks that appear in a pane of glass or other brittle material resulting from a projectile strike is related to the speed of the striking object. The team describes test trials, observations and results in their paper published in the journal *Physical Review Letters*.

Over the years, scientists have worked diligently to come up with different types of glass, ceramics, plastics, etc. that best suit their intended purposes. However, the current researchers note that little if

any effort has gone into the study of the cracking patterns that result when objects such as rocks or bullets strike panes of glass or brittle plastics. To address this question, the researchers conducted trials at a shooting range.

In order to determine any relationship between the cracks that appear in such structures and the speed with which they are struck, the researchers shot small metal balls at both glass and Plexiglas targets of varying thicknesses (0.5 mm to 3 mm thick). They used a gun that allowed for firing the balls at different speeds (up to 432 kilometers per hour). To observe what was occurring during impact, the team used high-speed video cameras.

Based on the analysis of 100 panes, the researchers found correlations between the number of cracks in the materials and the speed at which the balls were fired—generally, the number of cracks was directly proportional to the square root of the impact speed. The thickness and brittleness of the target had an effect on the results as well. After further analysis, they were able to create mathematical formulas that could predict the number of cracks that would appear, or working backwards, could derive the speed of the projectile after noting the characteristics of the glass or plastic and counting the number of resulting cracks.

While the team's results are highly specialized, dependent on a number of controllable factors, the researchers believe their study and results might prove useful in many other areas of study, from forensics to astrophysics or even to archeology.

More information: Star-Shaped Crack Pattern of Broken Windows, *Phys. Rev. Lett.* 110, 174302 (2013)
prl.aps.org/abstract/PRL/v110/i17/e174302

Abstract

Broken thin brittle plates like windows and windshields are ubiquitous in our environment. When impacted locally, they typically present a pattern of cracks extending radially outward from the impact point. We study the variation of the pattern of cracks by performing controlled transverse impacts on brittle plates over a broad range of impact speed, plate thickness, and material properties, and we establish from experiments a global scaling law for the number of radial cracks incorporating all these parameters. A model based on Griffith's theory of fracture combining bending elastic energy and fracture energy accounts for our observations. These findings indicate how the postmortem shape of broken samples are related to material properties and impact parameters, a procedure relevant to forensic science, archaeology, or astrophysics.

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