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Friction research casts doubt on fundamental physics law

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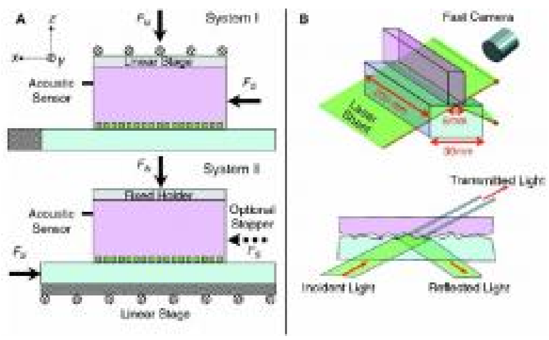

The experimental system. (A) A schematic view of the two loading systems used in these experiments. (B) A total internal reflection based method measures instantaneous changes in the real contact area, A(x,t), along the entire interface. For more details, please see the original publication: *Science* DOI:10.1126/science.1194777. Image credit: *Science*, AAAS.

(PhysOrg.com) -- New research on frictional slipping has revealed that some of the basic assumptions of introductory physics do not hold at small scales. The findings may be useful in the study of earthquakes.

A basic law of physics is that the force required to set an object moving equals the frictional force keeping the object stationary. The force from friction is determined by the coefficient of friction, the ratio of the sideways force to the force pushing down (the weight of the object). This relationship was first described by Leonardo da Vinci and further defined by Charles Coulomb and Guillaume Amontons centuries later.

Now a team led by physicist Oded Ben-David, a PhD student from the Hebrew University of Jerusalem studying the dynamics of frictional slips in carefully controlled laboratory experiments has found they could apply as much as five times more sideways force to the object than predicted by the coefficient of friction before the object would move.

The experiment's set up, described by Ben-David's supervisor Professor Jay Fineberg as the "stupidest system you could think about," was to place two 200 mm Plexiglass blocks together and use tons of force to press them together, and then try to push the top block sideways until it began to move. They used sensitive strain gauges to measure all the stresses on the blocks and high-speed cameras and lasers to track the points at which the blocks actually touched each other.

The results showed that the blocks, which were optically flat and appeared to be touching all along their surfaces, were actually only touching at a few hundred contact points, and at each of these points the sideways forces could be much larger than predicted by the coefficient of friction before the contacts broke and the block started to move. When the contact was ruptured waves similar to sound waves were propelled through the blocks, resembling a mini-earthquake.

Professor Fineberg said the blocks represented tectonic plates sliding against each other. When the force is strong enough to pull them apart a series of shock waves result. The experiments were able to measure all the variables, which is impossible in a real situation.

The shock waves are of three types: slow ruptures, moving well below the speed of sound, sub-Rayleigh waves traveling along the surface at the speed of sound, and supershear waves, traveling fast enough to cause a sonic boom. The type of wave produced depends on the stresses on the contact points, and the experiments showed that even small nuances could change the dynamics.

The most common type of wave in earthquakes is the sub-Rayleigh type, and there is some speculation that an earthquake in Izmit, Turkey in 1999 was a supershear type.

The results of the research, published in the journal *Science* may have implications for engineering and materials science, and could add to the scientific understanding of how earthquakes occur. Fineberg said it might also be possible in the future to trigger small earthquakes to prevent larger, more devastating quakes.

More information: The Dynamics of the Onset of Frictional Slip, Oded Ben-David, Gil Cohen, Jay Fineberg, *Science* 8 October 2010: Vol. 330. no. 6001, pp. 211 - 214. DOI:10.1126/science.1194777