The mechanism that puts the curl in the curling stone revealed

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Researchers from Uppsala University in Sweden can now reveal the mechanism behind the curved path of a curling stone. The discovery by the researchers, who usually study friction and wear in industrial and technical applications, is now published in the scientific journal *Wear*.

In the curling sport, the players shoot their stones along the ice so that they slowly slide towards the target area, almost 30 m away. The game has its name from the slightly curved "curled" path taken by the stone, when released with a slow rotation. This curled path is important since it is used to reach open spots behind previously played stones, or take out opponent stones behind hindering "guarding" stones. As soon as the player releases the stone, it is only affected by the friction against the ice. The friction can be slightly reduced, and therefore the sliding distance somewhat increased by intensively sweeping the ice just in front of the sliding stone.

If the player gives the stone a clockwise rotation as it is released, it curls to the right, while an anti clockwise rotating stone will curl to the left. The stone is heavy, almost 20 kg, and the rotation is very slow, typically 2-3 rotations during the roughly 25 seconds it takes to slide to the target. This is much too slow to cause the curved path taken by the ball in sports such as table tennis, tennis or soccer.

Despite years of speculations among the curlers and several scientific articles, so far no one has been able to present a good explanation to why the curling stones actually curl; "What puts the curl in the curling stone?". Interestingly, other rotating objects sliding over a surface curl in the opposite direction (make a simple test by sliding for example a glass turned upside down over a slippery floor).

However, the mechanism has now been revealed by researchers at Uppsala University in Sweden. Harald Nyberg, Sara Alfredsson, Sture Hogmark and Staffan Jacobson, who usually study friction and wear in technical and industrial material systems, describe in their article that the curved path is due to the microscopic roughness of the stone producing microscopic scratches in the ice sheet. As the stone slides over the ice the roughness on its leading half will produce small scratches in the ice. The rotation of the stone will give the scratches a slight deviation from the sliding direction. When the rough protrusions on the trailing half shortly pass the same area, they will cross the scratches from the front in a small angle. When crossing these scratches they will have a tendency to follow them. It is this scratch-guiding or track steering mechanism that generate the sideway force necessary to cause the curl.

The importance of having a proper roughness of the sliding surface on the stone to give it he expected trajectory, is since long known among curlers. However, this has not previously been coupled to the steering mechanism. While working on their model the Uppsala researchers experimented with pre-scratching of the ice in various ways, and could then observe that also non-rotating stones could be guided. Stones with very smooth, polished sliding surface were however not affected by the scratches. They also investigated the microscopic scratches made by the stones by moulding replicas of the ice, that were subsequently studied in microscopes.

More information: The new results have been published in "The asymmetrical friction mechanism that puts the curl in the curling stone", Nyberg, H., S. Alfredsson, S. Hogmark, and S. Jacobson, *Wear* (2013), dx.doi.org/10.1016/j.wear.2013.01.051

The researchers have also published a validation of older models, showing why they cannot satisfactorily explain the curling mechanisms: H. Nyberg, S. Hogmark, and S. Jacobson, "Calculated trajectories of curling stones sliding under asymmetrical friction - validation of published models". *Tribology Letters*, on line DOI 10.1007/s11249-013-0135-9, (April 2013)

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