

**SNOW PHYSICS**     **Cold research on ‘hot’ material.** Snow is a strange substance. From a physical point of view it is not at all cold – it is hot. Its changeability keeps not only snow physicists and avalanche researchers on the go, but also ski designers and tyre manufacturers.

The starting point is a dust particle in a cloud – a condensation nucleus around which steam accumulates and freezes to form a snow crystal. If several such crystals combine, a snowflake is born. The flake – a star-shaped formation containing around 100 trillion water molecules – swirls down to the ground and lands on other snow crystals.

What looks like a cuddly blanket draped over the silent winter landscape is, according to recent findings in snow research, an extremely changeable matter: No sooner has our snowflake landed, than it begins its metamorphism. “Snow behaves differently from most other material, which makes researching



Strange behaviour: Snow can creep like thick dough.

it particularly exciting,” explains Martin Schneebeli. He is head of the Research Group ‘Snow Physics’ at SLF and has been studying the changeability of snow in a laboratory where the influence of factors such as temperature, pressure and friction can be investigated separately.

### A ‘hot’ material

At temperatures far from its melting point – for example, at  $-100^{\circ}\text{C}$  – snow doesn’t change much. But the closer it gets in temperature to its melting point, the more mobile the molecules in the snow crystals become. Since the temperature of snow on Earth is never very far from its melting point of  $0^{\circ}\text{C}$ , it is, from a physical point of view, actually a ‘hot’ material. “This has an enormous effect on how the material behaves,” says Martin.

The snowflake merges with other ice crystals at their points of contact, i.e. it sinters, forming ice bridges that hold the snow layer together better. This is how powdery new snow turns into stable old snow. If it weren’t for this sintering process, the preparation of ski pistes, for example, would be impossible because no hard surfaces with a good grip would be formed. “This works best with small snow particles from which a lot of water vapour can escape,” explains Hansueli Rhyner, Head of SLF’s Research Unit ‘Snow Sports’. This is the case with artificial snow, or technical snow as the experts call it. It is therefore better suited for preparing pistes than natural snow.

Another special physical property of snow is its relatively high vapour pressure. This means that water molecules like to turn directly from their solid into their gaseous state. At colder spots, the molecules that have evaporated then cling again onto other ice crystals. In the process, new crystal structures may form. For example, cup-shaped and platelet-like crystals, known as surface

For further information, see:  
[www.slf.ch/snow-substance](http://www.slf.ch/snow-substance) and:  
[www.slf.ch/snow-metamorphism](http://www.slf.ch/snow-metamorphism)



Researchers use the SnowMicroPen to measure the layers in the snow cover quickly and accurately.

Photo: Jürg Schweizer, SLF

hoar crystals, form those dreaded weak layers in the snow cover that are prone to develop into avalanches.

### **Snow encourages creativity**

Detecting such weak layers is crucial if you want to estimate the risk of avalanche release. One way of doing this is to inspect snow profiles visually and assess them by hand. Digging them out is sweaty work. Assessing snow profiles is still important for stability tests, but having a look inside the snow cover can be done more quickly and accurately today using the SnowMicroPen (a high-resolution penetrometer) developed at SLF.

The portable probe is placed on the snow surface. The tip bores into the snow and records the boring force required every four micrometres. Each layer, for instance, a thin ice crust, hoar crystals or new snow, produces a different force-distance signal. This makes it possible to measure over larger areas the properties of the weak layers, which are often just a few millimetres thick. “The instrument is now standardly used in assessing snow cover,” says Martin.

Snow researchers have taken over one technology from medicine: micro-computed tomography (micro-CT), with which tissue can be assessed without destroying it. A CT scanner was specially adapted for snow in SLF’s cold laboratory, and can be used to observe the transformation of snow probes ‘live’ over longer time periods and determine the spatial arrangement of ice and air in snow precisely. The data can also be used to check, for example, the accuracy of snow-cover models.

### **The colder it is, the more the friction**

Wherever snow is involved, its mutability puts technology to the test. Winter tyres, for instance, must have the best possible grip in snow with different consistencies at variable temperatures. SLF researchers therefore have developed a machine specially to study the friction between rubber and any kind of snow more precisely. Tyre manufacturers use the resulting data to develop better winter tyres.

Skiing as a sport also depends on the snow’s ‘mood’. If it is too warm, a wonderful carving piste gets turned into slushy snow. If it is too cold, it slows skiers down: “The colder the snow, the more the friction,” explains Hansueli Rhyner. The optimal temperature of snow for skiing is between  $-3$  and  $-5^{\circ}\text{C}$  because then the film of water that the skis glide on is ideal.

Our snowflake has therefore turned back into water under the skis. ‘Hot’ snow is always close to its melting point, which makes it fascinating for snow researchers, but also poses a challenge. They are, however, working out, step by step, the secrets of this mutable natural substance. Their findings should, in the end, be of benefit not only for avalanche protection and climate research, but also for the car and snow-sport industries. *(bki)*