German
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Hypersonic flow made visible by DLR researchers

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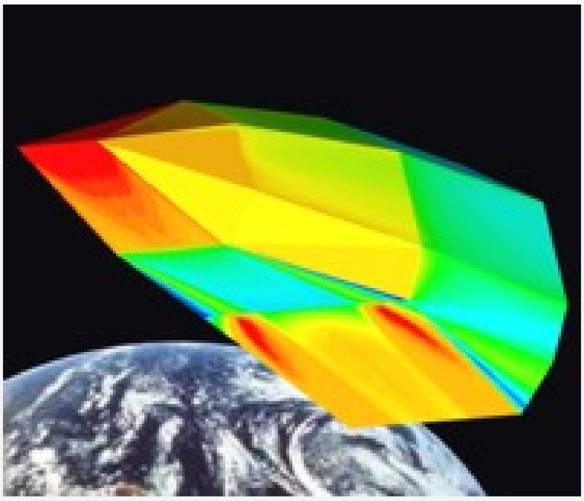
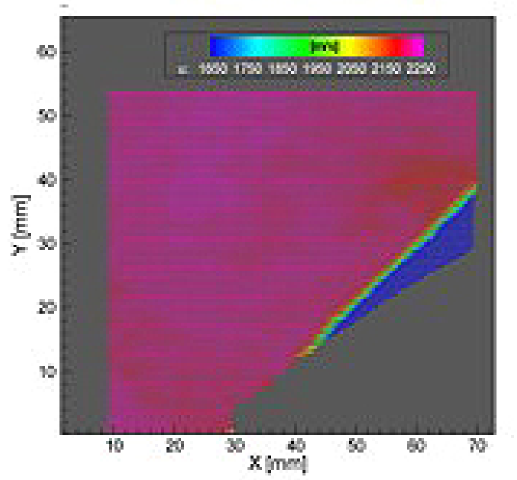


Project SHEFEX

Even after decades of space exploration, we still do not know how the extreme temperatures experienced by spacecraft during re-entry influence their aerodynamic performance. Flow researchers of the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) in Göttingen have now made it easier to do calculations on these complex phenomena. In order to do so, they visualised hypersonic flow inside a wind tunnel in Göttingen at speeds that had never been observed before, using an optical technique for measuring velocity fields that was originally developed for use in aeronautics research.

Flow determination at 2 250 metres per second

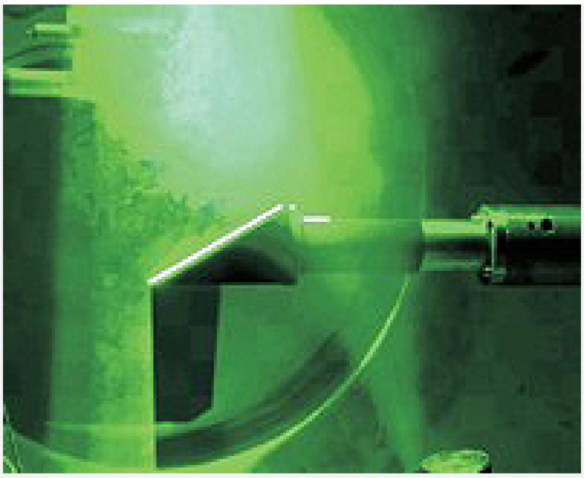
The researchers determined the flow on a so-called wedge model at 2 250 metres per second - i.e. seven times the speed of sound, or 8 100 kilometres per hour. Until now, measuring flow velocities in the hypersonic range was very difficult, and in fact it could only be done to a very limited extent. "We have now made progress in a field about which we knew next to nothing before", says Dr Klaus Hannemann of the DLR Institute for Aerodynamics and Flow Technology (DLR-Institut für Aerodynamik und Strömungsforschung). For the first time, phenomena such as turbulence at hypersonic speeds can be visualised and investigated using accurate data. In addition to this, the efficiency of large hypersonic wind tunnels, which are time-consuming and costly to operate, can be improved significantly. "This new method allows us to obtain more information from a single experiment", according to Hannemann. The experiments are carried out in the High Enthalpy Shock Tunnel Göttingen, one of the most important large-scale facilities in Europe for research into hypersonics and spacecraft re-entry.



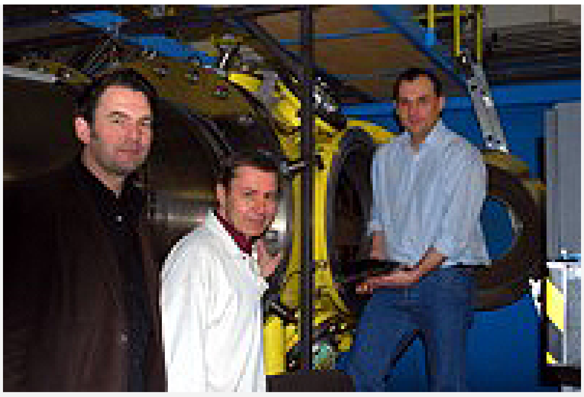
A new record: measuring at 2 250 metres per second

Particle Image Velocimetry (PIV) measurement technique can now also be used for high speeds

The Göttingen-based scientists used Particle Image Velocimetry, a contactless measurement technique originally developed for use at low speeds in aeronautics research. The underlying principle of PIV is the observation of small tracer particles that are added to a flowing gas. These tracer particles are illuminated briefly by what is known as a laser light sheet, and a camera records the light they reflect at two different moments separated by a short interval. Computer analysis is then carried out on the frames to determine how the tracer particles have shifted in the time between the two exposures. The current speed at many different points in the flow can be calculated from the displacement of the tracer particles and the elapsed time.


Wedge model inside the wind tunnel in Göttingen

Up to now, the PIV measurement technique could not be used for high-speed flows. At high speeds, the injection of particles was very problematic. In order to solve this problem, the researchers used to their advantage the operating principle of the High Enthalpy Shock Tunnel Göttingen in which they conducted their tests: In order to achieve very high speeds, extremely high temperatures of several thousand degrees Celsius are needed. At these temperatures, miniscule particles with a diameter of about one micron are formed spontaneously. "These naturally available particles have the right shape, density and size to be used for measurements", says Dr Andreas Schröder, who conducted the tests together with Dr Jan Martinez. Within one millionth of a second, speeds were measured at over 6 000 points in the flow field at the same time.



DLR scientists at the High Enthalpy Shock Tunnel Göttingen

The test results were corroborated by computer simulations. In the future, numerical methods used to design spacecraft will be able to be verified using the PIV measurement technique. To this end, the measurement method will be tested at even higher speeds in the near future. According to Hannemann, "this will allow a better understanding of the effects of the high temperatures experienced by spacecraft during re-entry".

The experiments are conducted as a joint project of the Spacecraft Department (Abteilung Raumfahrzeuge) in Göttingen (led by Dr Hannemann) and the Department of Experimental Methods (Abteilung Experimentelle Verfahren, led by Dr Jürgen Kompenhans) of the DLR Institute for Aerodynamics and Flow Technology.

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