Laboratory study of Rayleigh-Brillouin scattering for measuring the winds of the Earth

W. Ubachs, M. O. Vieitez, B.J. van dien, and E.-J. van Duijn – Laser Centre Vrije Universiteit Amsterdam
B. Witschas and O. Reitebuch – Deutsches Zentrum für Luft und Raumfahrt

Motivation

Total number of vertical wind profiles on 26-Sep-2005

Wind profiles are the main missing component of the global observing system over oceans, tropics.

In 2011 ESA plans to launch a satellite to measure winds on Earth.

- Depending on the pressure, the deviation of the model Gaussian shape deviates 6% at the wings and 10% at the center frequency and 1% on the wings.

Testing the Tenti Model

Experimental conditions (λ, T, gas mixture used, pressure, turbulence, etc.)

- Transport coefficients (shear viscosity, bulk viscosity, sound velocity, internal heat capacity, etc.)

SRBS Experiment

The next step is to use the experimental results to calculate the transport coefficients

SRBS Model

Some transport coefficients are not sufficiently known (bulk viscosity)

Results

Nitrogen

Air

Humidity

- Air: Sensible effect of water vapor in the atmosphere

Bulk Viscosity

An underlying issue of the TENTI models is that it is based on the gaseous transport coefficients, such as: heat conductivity, shear viscosity, heat capacity of internal degrees of freedom, and an elusive bulk viscosity parameter, \( \eta_b \). The latter is not well-known at optical frequencies, and can be derived from the present measurements.

Conclusion from measurements:

- Tenti S6 model represents the SRBS shape better than the Tenti S7 model.
- Gaussian shape approximation has deviations up to 10%.
- Depending on the pressure, the deviation of the model from the measurement can amount to 7-8%, while at atmospheric pressures the deviations are on the 2% for the center frequency and 1% on the wings.

Results:

- Gaussian shape represents poorly the air SRBS shape, only having 2% deviation at 500 mbar. At 1000 mbar, the Gaussian shape deviates 6% at the wings and 10% at the wings.
- Tenti S6 model gives a better representation than S7.

Bulk Viscosity

Fit of a value for the bulk viscosity \( \eta_b \) for nitrogen gas.