The current definition of the temperature unit kelvin is based on the triple point of water. The relative accuracy of about 2·10^{-7} of this definition is basically limited by the "purity" of the water in the triple point cell. In order to meet future demands for temperature measurements, it is desirable to redefine the kelvin by fixing the value of the Boltzmann constant \( k_B \) [1]. The current value for the Boltzmann constant \( (k_B) \) has a relative uncertainty of 1·10^{-6}, and this must be improved before redefining the temperature unit.

Metrology institutes are collaborating within a European research programme on a new determination of \( k_B \). The project investigates several quite different methods, including the spectroscopic determination of \( k_B \) suggested first in 2002 [2]. Preliminary results from the French and Italian groups were published in 2007 and 2008 [3-4]. Our work complements the work of our collaborators by the use of different molecular species and by exploring the possibility of using a gas cell based on hollow-core optical fibers. Furthermore, we propose a recursive least squares analysis of the very large datasets in order to obtain a reliable combined uncertainty of \( k_B \) taking into account the full covariance matrix of all relevant quantities.

The Doppler broadened lineshape of a single molecular absorption line at low pressure is a Gaussian profile with a 1/e half width given by

\[
\Delta v_0 = \sqrt{\frac{2k_B T v^2}{mc^2}}
\]

Here \( v \) is the frequency of the molecular transition, \( m \) is the molecular mass, and \( T \) is the temperature of the gas. For the \( P(16) \) line of \( ^{13}\text{C}_2\text{H}_2 \) acetylene, the frequency \( v \) is known at the 10^{-10} level and the mass \( m \) is known at the 6·10^{-8} level. Thus, the uncertainty of \( k_B \) can be improved by an accurate determination of the gas temperature and the linewidth.

The Doppler width of the \( P(16) \) acetylene line is about 225 MHz at \( T = 273 \) K. Thus, a laser stability at the kHz level is required for improving the uncertainty of \( k_B \). Further complications arise due to the always present pressure broadening at finite pressure levels, which leads to modifications of the line shape. Furthermore, even with a state-of-the-art laser power stabilization, the power fluctuations during a measurement have a significant contribution to the overall uncertainty.