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Quantification of non-LTE contributions to OH rotational temperatures based on VLT/X-shooter, VLT/UVES, and TIMED/SABER data

Stefan Noll (1), Wolfgang Kausch (2,1), Stefan Kimeswenger (3,1), Bastian Proxauf (1), Stefanie Unterguggenberger (1), and Amy M. Jones (4)

(1) Institute for Astro- and Particle Physics, University of Innsbruck, Innsbruck, Austria (stefan.noll@uibk.ac.at), (2) University of Vienna, Department of Astrophysics, Vienna, Austria, (3) Instituto de Astronomía, Universidad Católica del Norte, Antofagasta, Chile, (4) Max Planck Institute for Astrophysics, Garching, Germany

The hydroxyl (OH) airglow emission is very valuable for estimating atmospheric temperatures at about 87 km because it is relatively easy to measure. The usual approach is based on intensity ratios of OH lines with low rotational upper levels of a given band and the assumption of a Boltzmann distribution of the level populations consistent with the ambient temperature. However, this assumption can be unrealistic if the frequency of thermalising collisions is too low, which is most likely at the highest emission altitudes.

We have investigated the amounts of possible non-LTE contributions to the measured OH rotational temperatures depending on the selected lines, band, and time of observation. For this, we used several hundred spectra from the echelle spectrograph X-shooter at the Very Large Telescope (VLT) at Cerro Paranal in Chile. These data with a very wide wavelength coverage allowed us to simultaneously measure temperatures for 25 OH bands and two O_2 bands. The latter were used to obtain reference temperatures, which is possible since the radiative lifetimes of the upper states are sufficiently long for establishing full thermalisation for the populations of the different rotational levels. For a comparison of the resulting temperatures, a correction of the different emission altitudes is required. Hence, we also used CO_2-based temperature and OH and O_2 emission profile data from the SABER multi-channel radiometer on the TIMED satellite.

The altitude-corrected OH rotational temperatures show significant non-LTE effects for higher vibrational levels of the upper state v' and especially even v'. The maximum deviations of more than 10 K were found for $v' = 8$. The non-LTE effects can vary within a range of a few K. The studied nocturnal variations indicate that the non-LTE contributions increase when the emission layer rises.

Finally, we will also present first results for several thousand spectra taken with the VLT high-resolution optical echelle spectrograph UVES. Compared with the 3.5 years of data for X-shooter, our UVES data set covers a much longer period of about 15 years, which allows us to also study long-term variability of non-LTE effects. The analysis comprises five OH bands with v' between 5 and 9, which could be measured in all spectra.