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SPECTRAL LINE WIDTHS IN STELLAR ATMOSPHERE MODELLING IMPROVEMENTS, CHALLENGES, PERSPECTIVES

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Accurate line synthesis using model spectra has always been at the foundation of the detailed spectral analysis of stellar parameters. Often, many line parameters like oscillator strengths and damping constants have been fine-tuned in line-by-line analysis in a semi-empirical manner. But as atmosphere models have grown in complexity, they now may include millions of atomic, and literally billions of molecular lines. The latter in particular have become necessary to accomodate as models have advanced well beyond the end of the classical main sequence into the substellar domain, approaching now with spectral class Y brown dwarfs the temperature regime of habitable planets. The same types of models may also be applied to the atmospheres of extrasolar planets; initially hot Jupiters and other gas giants, but now targetting Neptune- and super-Earth-type planets as well. This progress towards cooler temperatures requires the inclusion of not just diatomic molecules, but tri-, tetra-, pentatomic and even more complex compounds. These display the aforementioned extremely complex bands with some $10^8 - 10^9$ transitions contributing to the opacity. At the same time, more powerful high-resolution spectrographs on VLT-class telescopes now allow to study even the faintest red dwarf stars and some brown dwarfs at a resolution that used to be available only for bright stars. To reproduce the full comlplexity of these spectra, atmosphere models therefore have to rely largely on theoretically determined line parameters. For example, collisional damping widths based on quantum-mechanical calculations have become available for some thousands of atomic lines under typical stellar conditions, and detailed line shapes for much more complex broadening as it occurs in very cool brown dwarf atmospheres, exist for a few important transitions. I will discuss how these data have driven the improvement of high-resolution spectral synthesis, and which data are needed most urgently to keep up with the further advance towards cooler sources, different metallicities and high-quality observations covering a wide spectral range from the optical to the mid-infrared.