Spectrum and Energy Levels of Singly-Ionized Chromium (Cr II): New Observations from the Vacuum Ultraviolet to the Infrared

Craig J. Sansonetti and Gillian Nave

National Institute of Standards and Technology, Gaithersburg, MD 20899

Abstract. Chromium is the third most abundant of the iron group elements and has a complex spectrum that is densely distributed over a wide spectral region. Lines of singly-ionized chromium (Cr II) are prominent in the spectra of a wide variety of astrophysical sources, and accurate laboratory data are essential for interpreting astronomical observations. Until recently the only comprehensive study of the Cr II spectrum in the literature was the six-decade old work of Kiess [1]. A large number of additional energy levels were located by S. Johansson of Lund University and are reported in a compilation of energy levels of the iron group elements [2]. Unfortunately, Johansson's work was never published. As a result no classified lines have been reported for 60% of the known energy levels and the uncertainty of the level values cannot be reliably determined.

We have re-observed the spectrum, emitted in Cr/Ne hollow cathode lamps, from 1130 Å to 5.5 µm using the NIST 10.7 m normal incidence vacuum spectrograph, the FT700 UV/Vis Fourier transform spectrometer (FTS), and the 2 m UV/Vis/IR FTS. We recently completed a description of the UV spectrum with new measurements of more than 3600 lines and re-optimization of 651 energy levels [3]. This work is being extended with new FT spectra covering the visible and IR regions that are now being analyzed. These spectra are of particular interest because new astronomical instruments on both space and ground-based telescopes have pushed the region of high-resolution astronomical spectroscopy to the red and IR. There are currently no lines of Cr II in the literature at wavelengths longer than 7311 Å, and Ritz wavelengths calculated from the Cr II energy levels cannot match the accuracy of the best astronomical observations.

From our present preliminary results, we estimate that we will identify about 800 additional Cr II lines at wavelengths longer than 3955 Å. These data will provide precise wavelengths for interpretation of astronomical spectra and allow further improvement in the accuracy of high lying energy levels. They will also provide the first precise values for levels of the high angular momentum configurations $3d^4 5g$ and $3d^4 6g$, which have no observable transitions at shorter wavelengths. These configurations are expected to produce prominent lines in the infrared spectra of astrophysical objects.

Acknowledgement. This work is supported by the National Aeronautics and Space Administration under interagency agreement NNH10AN38I.

1. C. C. Kiess, J. Res. Natl. Bur. Stand. **47**, 385 (1951).
2. J. Sugar and C. Corliss, J. Phys. Chem. Ref. Data **14**, Suppl. 2, 279 (1985).
3. C. J. Sansonetti, G. Nave, J. Reader, and F. Kerber, Astrophys. J. Suppl. **200**, in press (2012)

PACS: 32.30.Jc, 32.30.Bv, 32.10.-f