

Keck telescope constraint on cosmological variation of the proton-to-electron mass ratio

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APPENDIX B: SUPPORTING INFORMATION

Table B1 and Fig. B1 are the complete versions of Table 1 and Fig. 1. Captions for both Table B1 and Fig. B1 follow but only Fig. B1 is presented in this document. Table B1 is instead provided in machine-readable ASCII format in the online version of the paper.

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Table B1. Catalogue of the most accurate and precise laboratory parameters for fitting H₂ absorptions lines. Represented are all allowed Lyman and Werner H₂ transitions between the lowest 8 rotational levels in the ground and excited states with excited state vibrational quantum numbers up to 20 and 6 for Lyman and Werner transitions, respectively. The first column provides a short-hand notation for the transition: letters denote a Lyman (L) or Werner (W) line and the branch, where P, Q and R represent $J' - J = -1, 0$ and 1, respectively, for J and J' the ground state and excited state J -levels, respectively; the first integer is the excited state vibrational quantum number and the second is J . The second column gives the most precise reported laboratory wavelength and its $1-\sigma$ uncertainty is given in the third column; the fourth column provides the reference: 1 = Bailly et al. (2009), 2 = Ubachs et al. (2007) (a suffix “a” refers to directly measured wavelengths while “b” refers to wavelengths calculated from directly measured lines via combination differences) and 3 = Abgrall et al. (1993) for the excited state energy levels with ground states derived directly from Jennings et al. (1984). Note that wavelengths with reference 3 are much less precise than those from references 1 and 2. The fifth column gives the oscillator strengths which were calculated from the Einstein A coefficients given by Abgrall et al. (1994). The sixth column gives the (natural) damping coefficients which were calculated from the total transition probabilities (A_{ℓ}) in Abgrall et al. (2000). The final column gives the sensitivity coefficients calculated in Ubachs et al. (2007) which have estimated uncertainties of typically $< 5 \times 10^{-4}$ (see main text).

Figure B1. All regions of the J2123–0050 Keck spectrum fitted simultaneously in our analysis. The spectrum (black histogram) is normalized by a nominal continuum (upper dotted line) fitted over large spectral scales. Local linear continua (upper dashed lines) and zero levels (lower dashed lines) are fitted simultaneously with the H₂/HD and broader Lyman- α lines. The fits are shown with solid grey/green lines. H₂/HD transitions are labelled and their constituent velocity components are indicated by grey/green tick-marks immediately above the spectrum. Higher above the spectrum are tick-marks indicating the positions of Lyman- α lines (blue) and Fe II lines (red). Note that the metal-line velocity structure is constrained with the Fe II $\lambda 1608 \text{ \AA}$ transition shown in the final panel of the figure. The residual spectrum (i.e. [data] – [fit]), normalized to the $1-\sigma$ errors (faint, horizontal solid lines), is shown above the tick-marks.

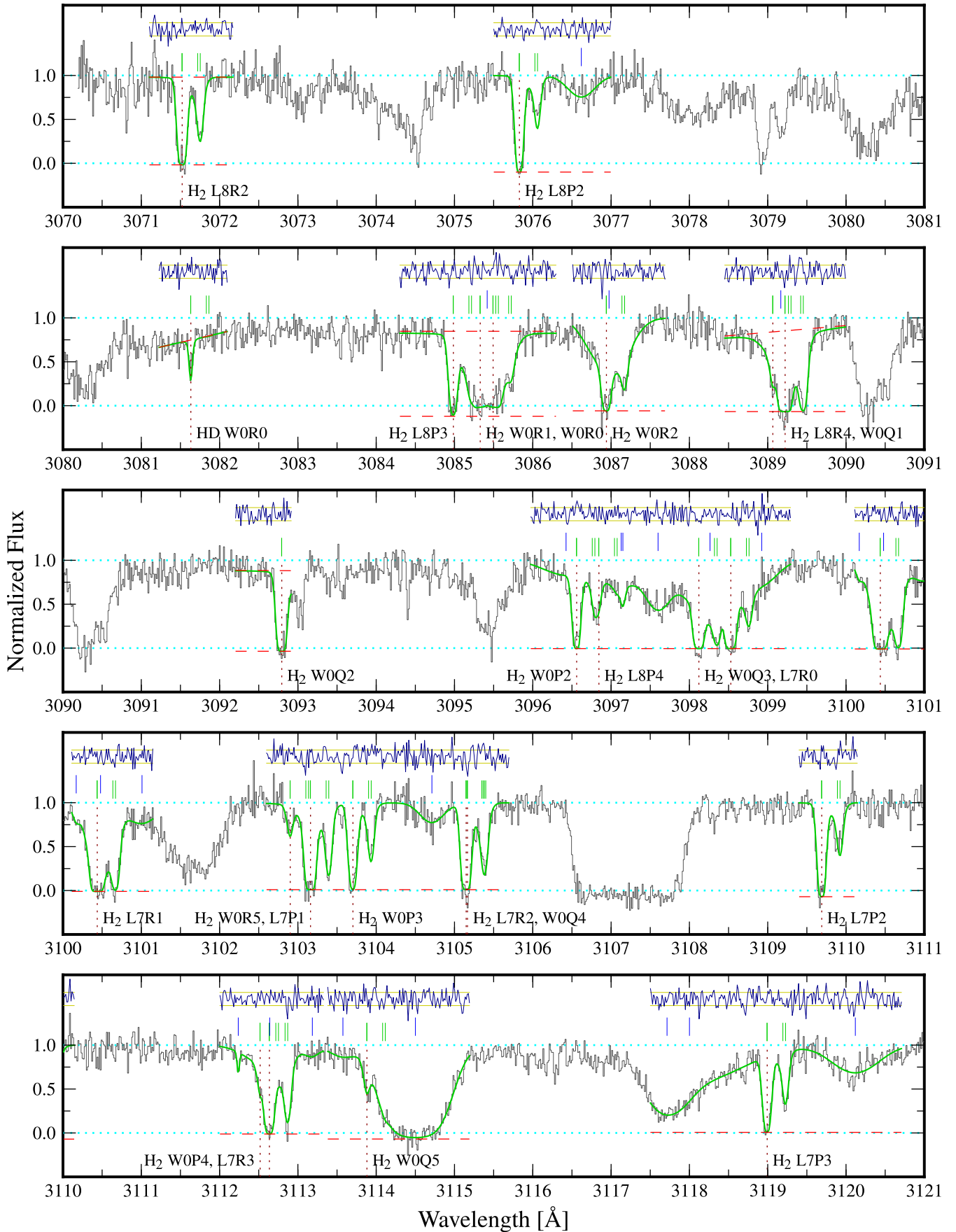


Figure B1 – continued

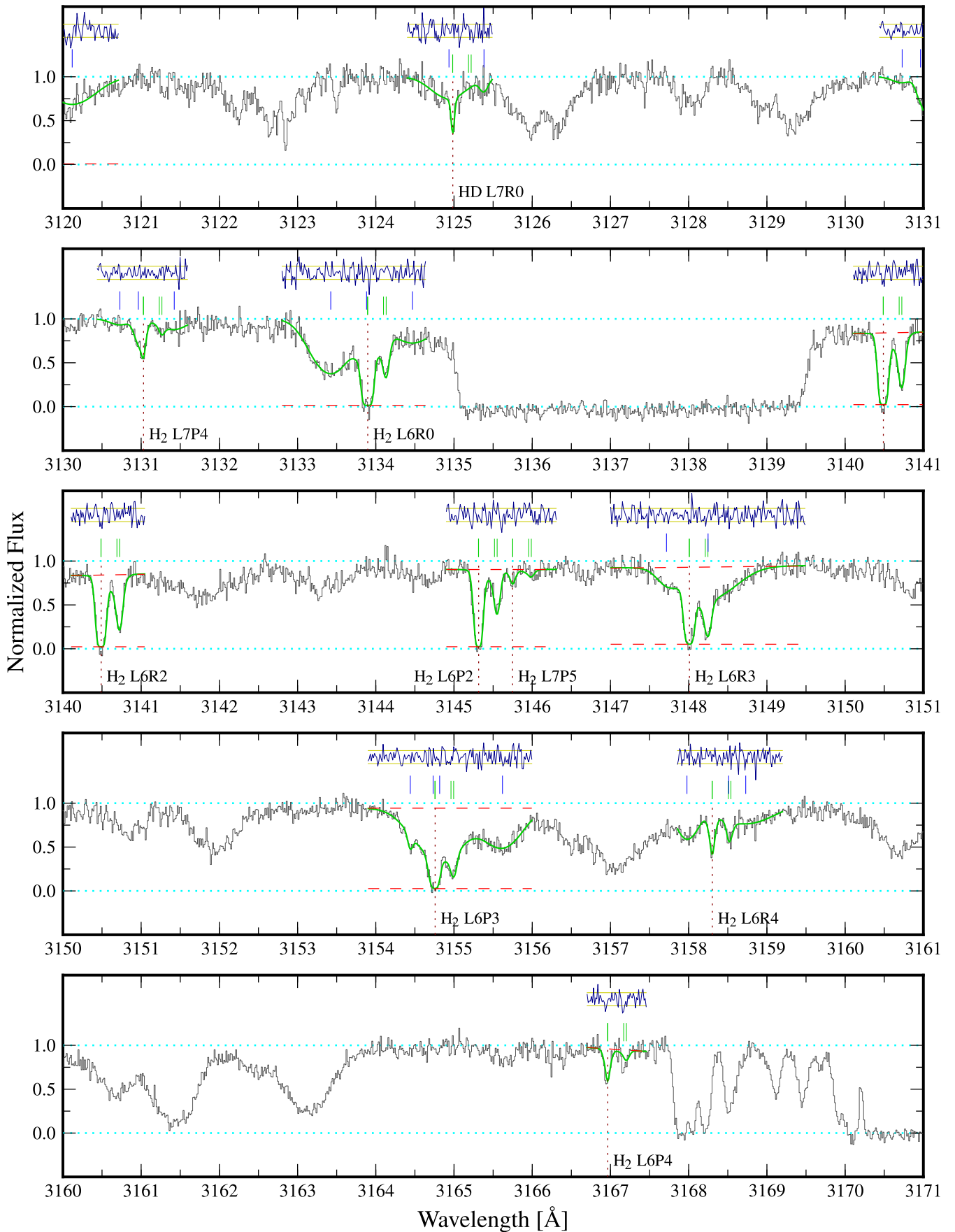


Figure B1 – continued

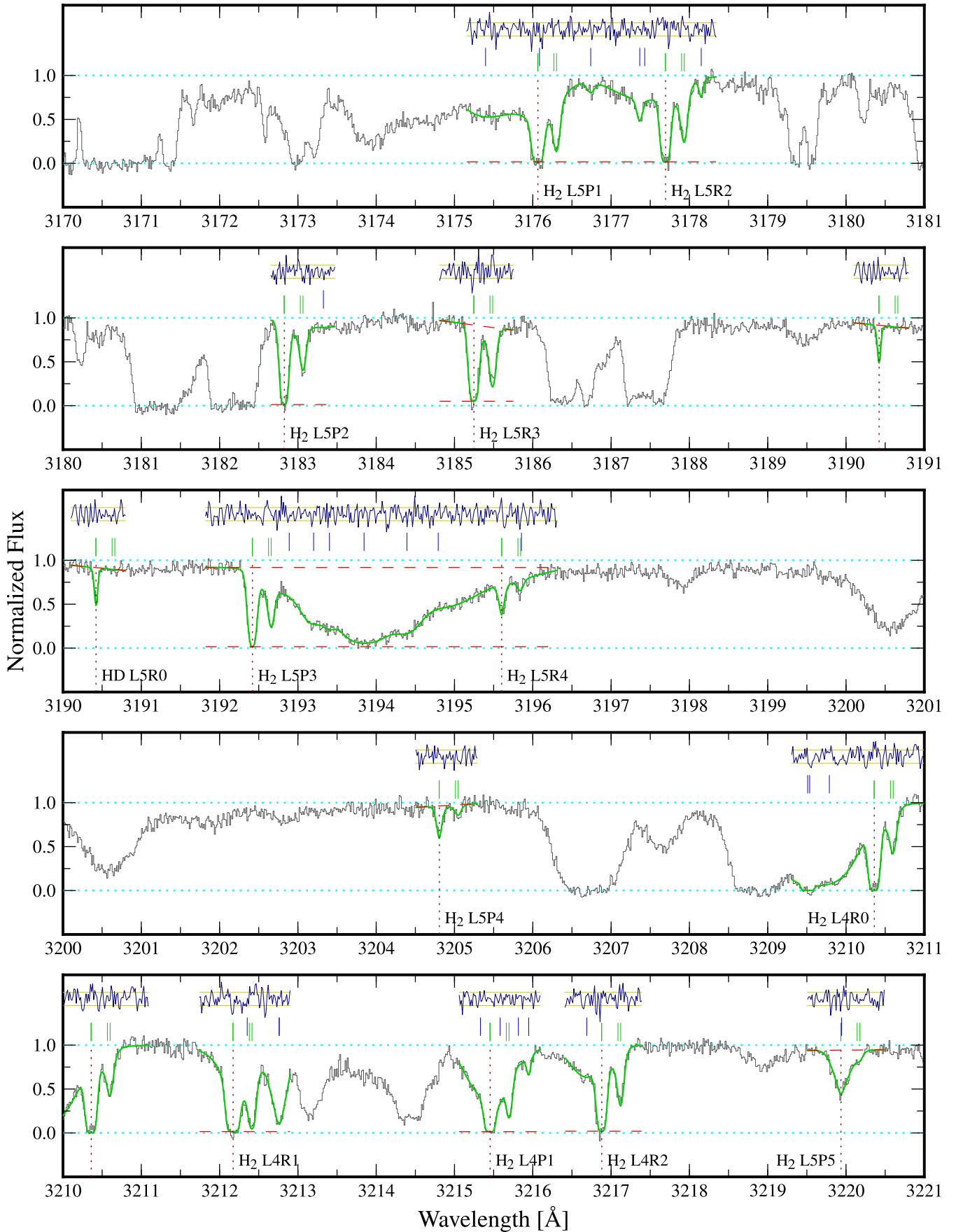


Figure B1 – *continued*

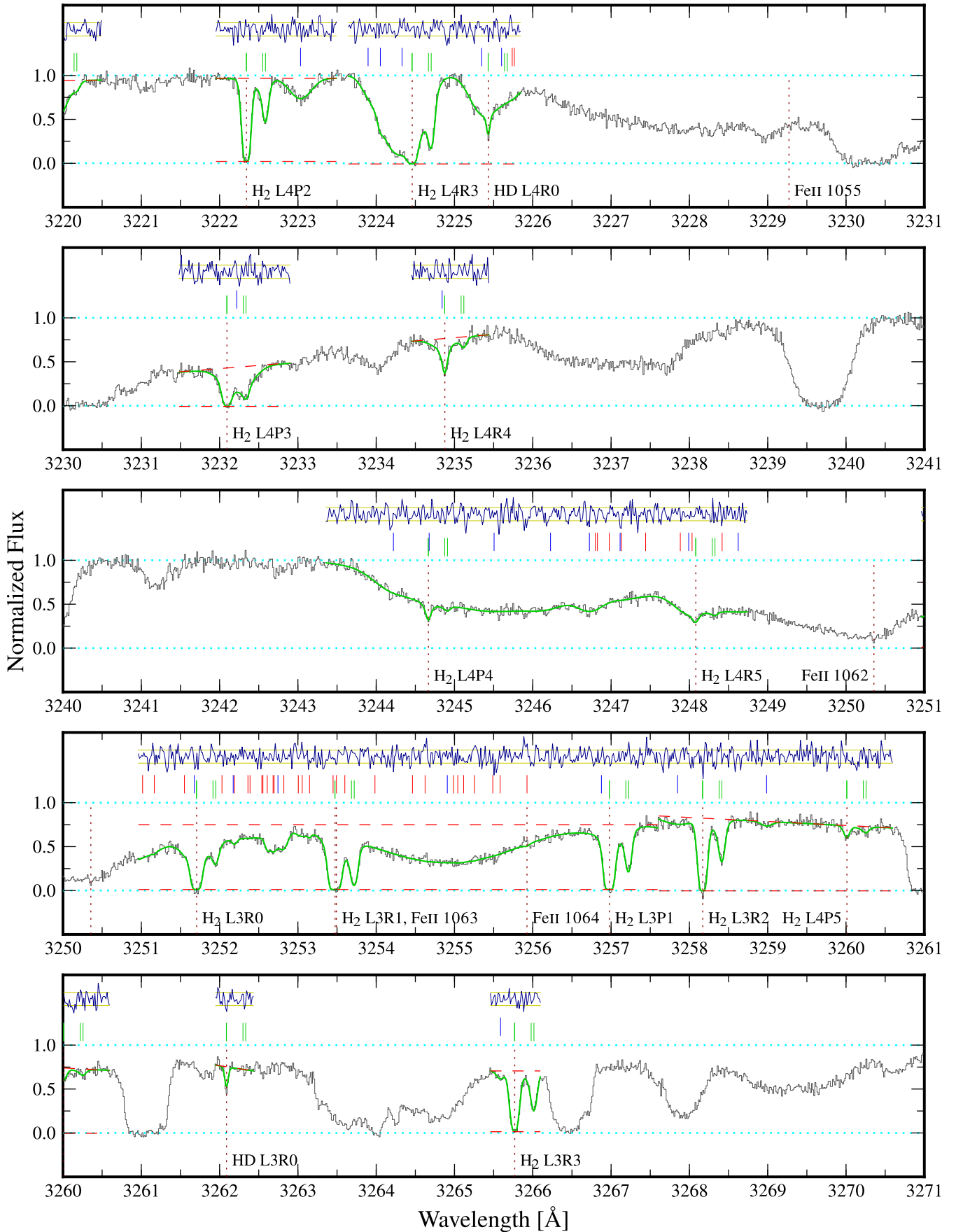


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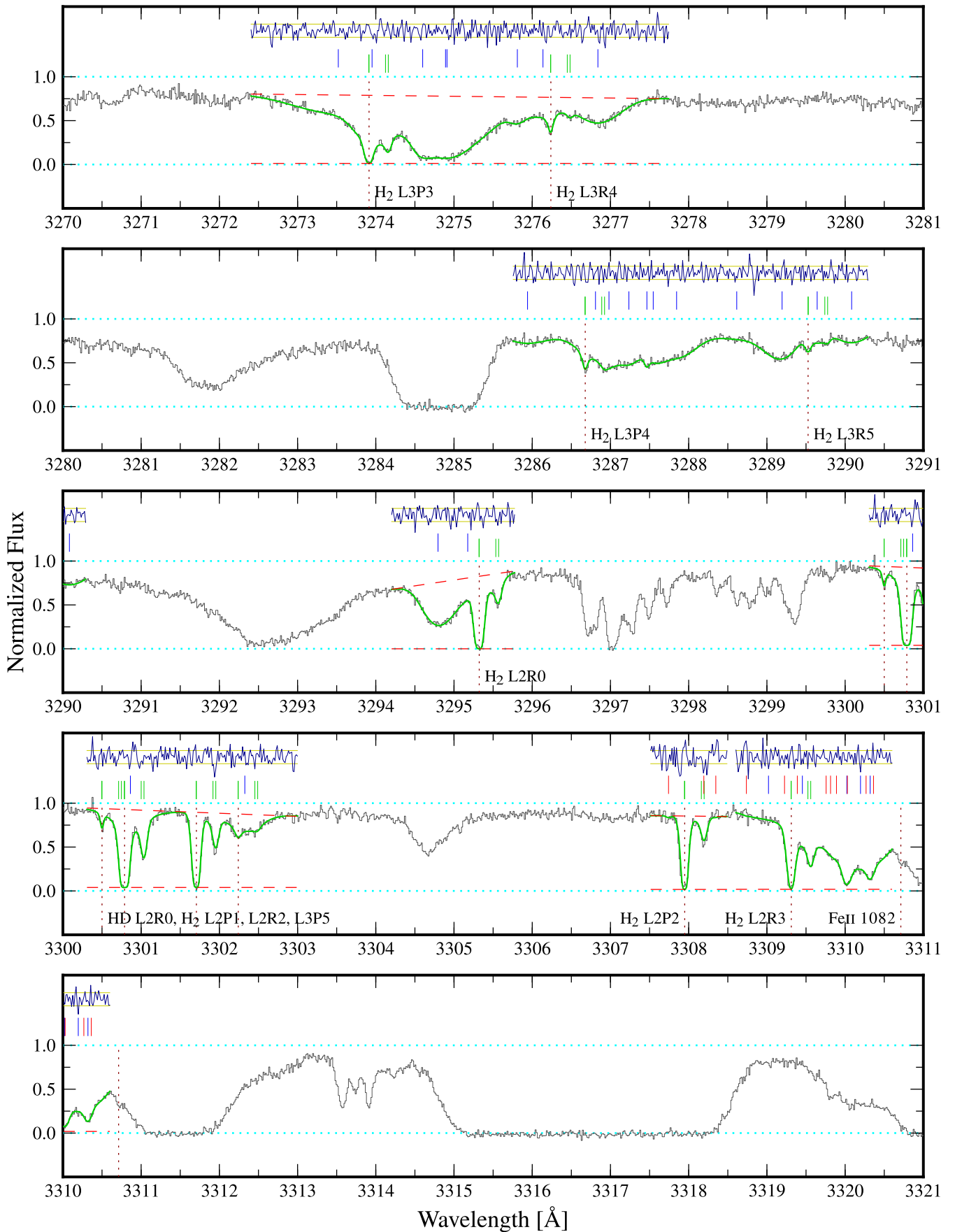


Figure B1 – continued

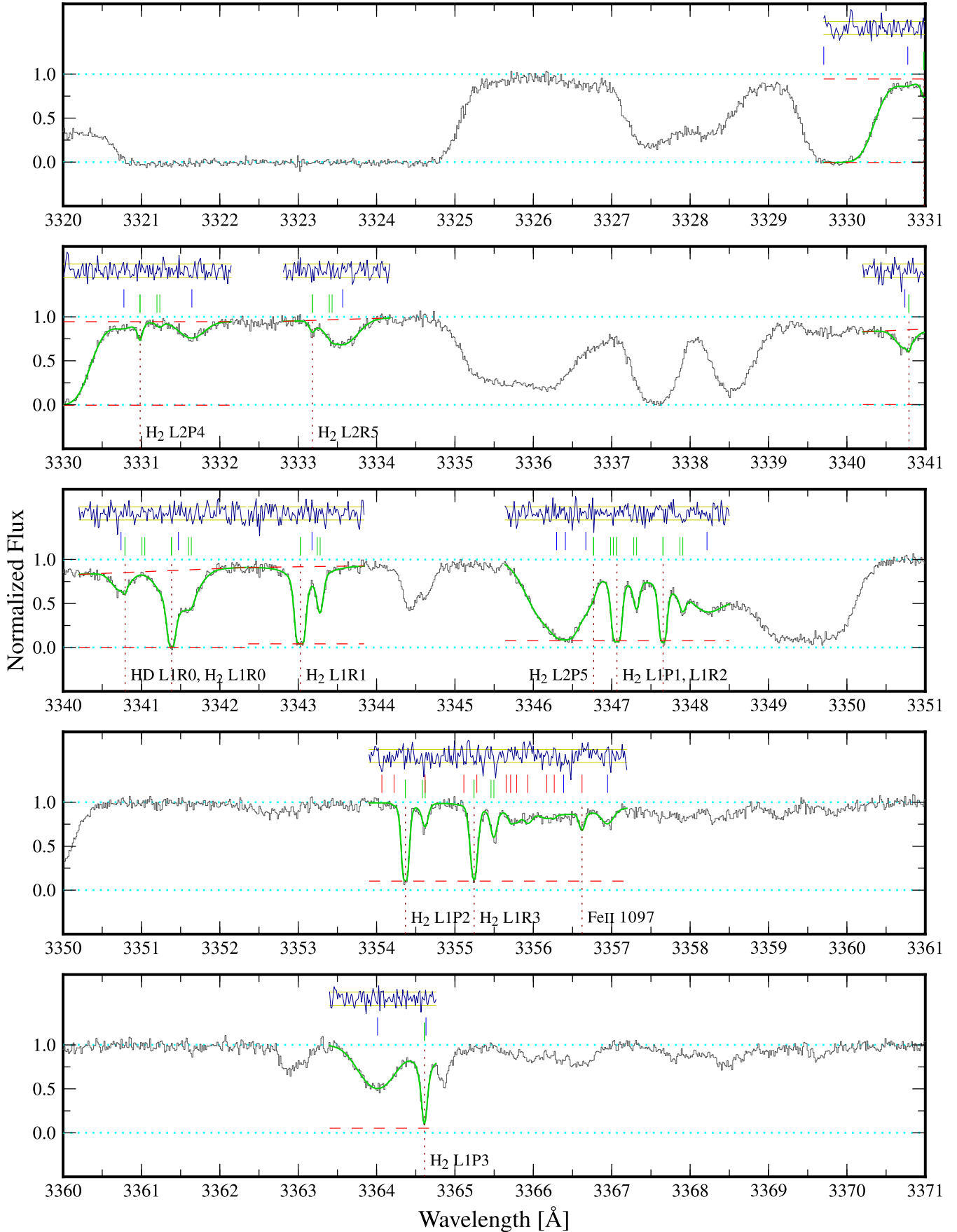
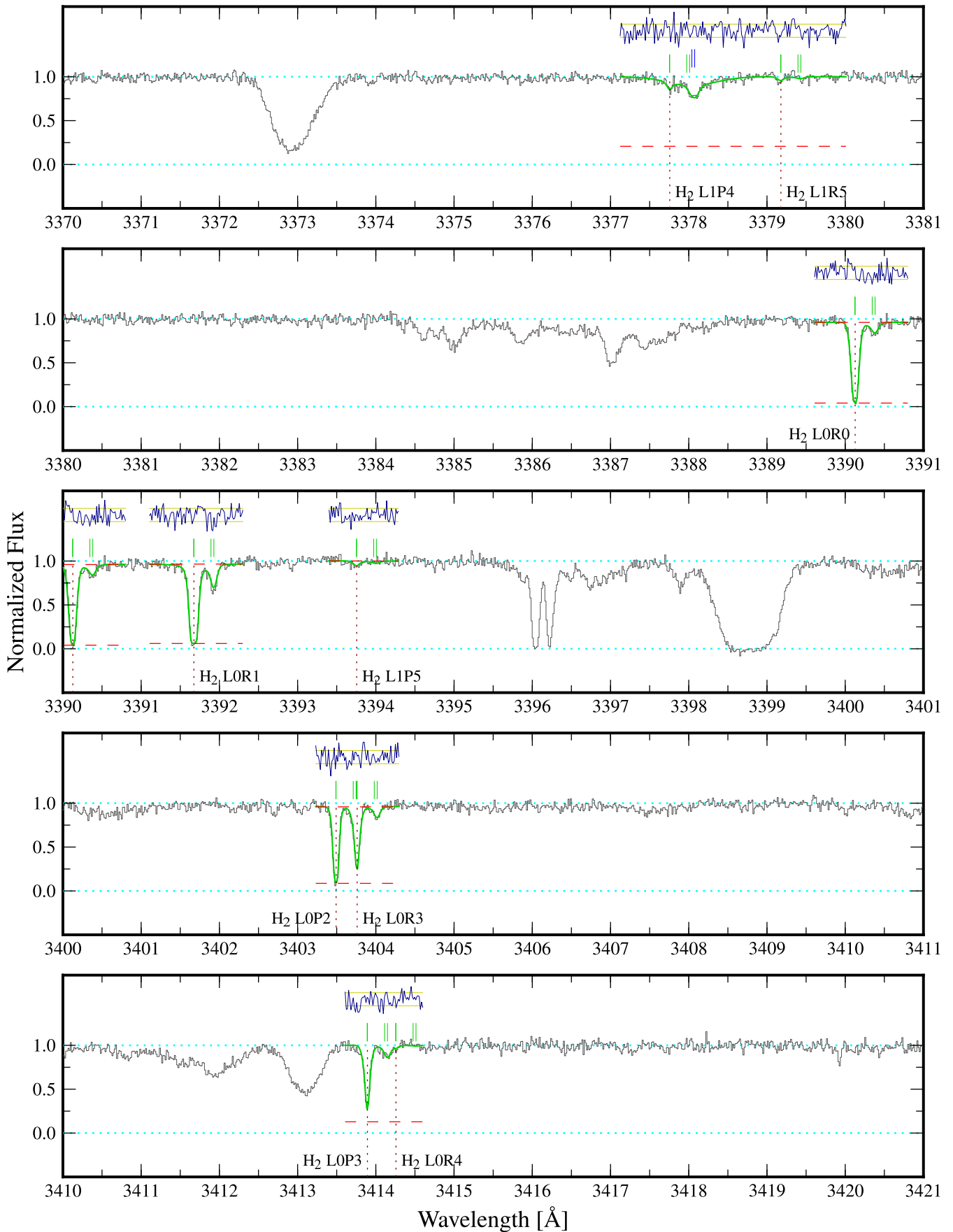


Figure B1 – continued

Figure B1 – *continued*

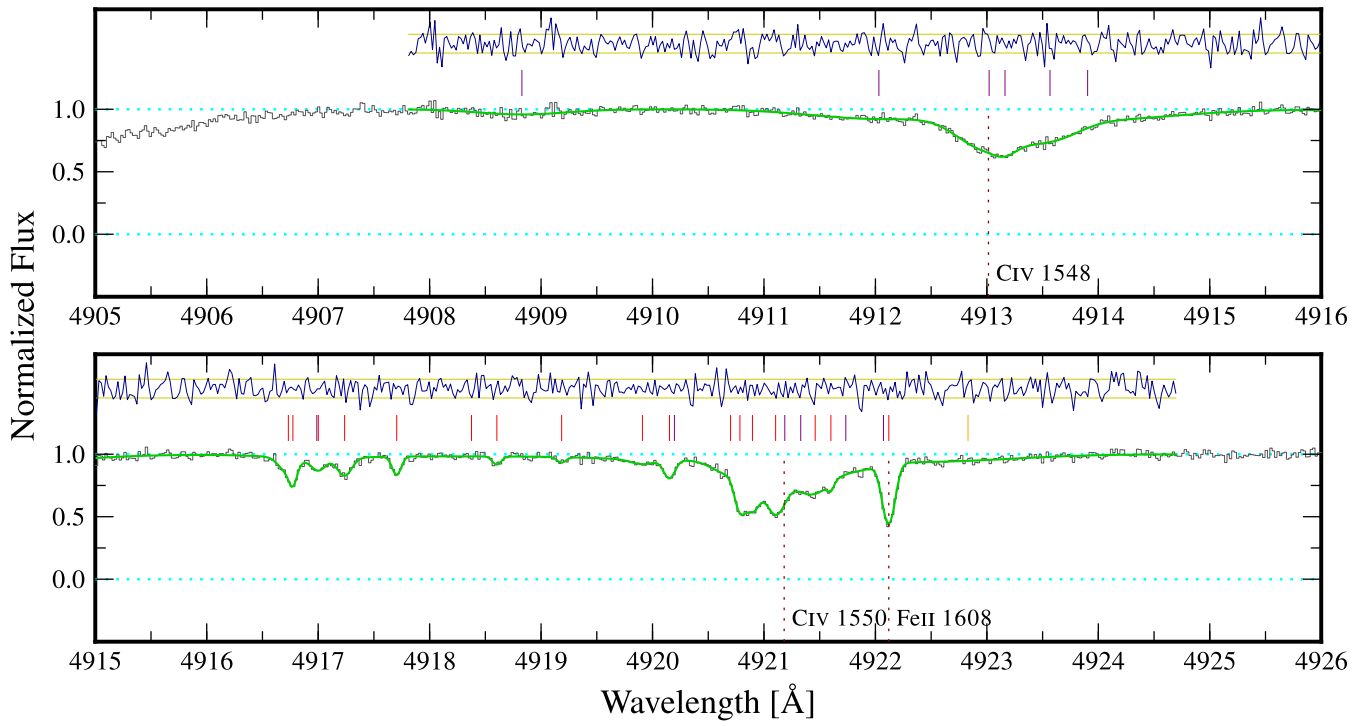


Figure B1 – continued