TORSION-ROTATION-VIBRATION EFFECTS IN THE $\nu_{20}$, $2\nu_{21}$, $2\nu_{13}$ AND $\nu_{21} + \nu_{13}$ STATES OF $CH_3CH_2CN$

ADAM M. DALY, JOHN C. PEARSON, SHANSHAN YU, BRIAN J. DROUIN, *Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109*; C. BERMÚDEZ, J. L. ALONSO, *Grupo de Espectroscopia Molecular (GEM), Edificio Quifima, Laboratorios de Espectroscopia y Bioespectroscopia, Parque Cientfíco, Universidad de Valladolid, 47011 Valladolid, Spain*.

Ethyl cyanide, $CH_3CH_2CN$, is a highly abundant molecule in hot cores associated with massive star formation where temperatures often approach 200K. Astrophysicists would like to use the many thousands of observed lines to evaluate thermal equilibrium, temperature distributions, heating sources, and radiative pumping effects. In spite of a recent partial success in characterizing the $\nu_{20}$ and $\nu_{12}$ vibrational states[a], many aspects of the spectroscopy of the $\nu_{20}$ state are not adequately characterized. Torsional splittings in the b-type spectrum of $\nu_{20}$ are typically a few MHz and many a-type transitions also show resolved torsional splittings, both are incompatible with the expected 1200 cm$^{-1}$ barrier to internal rotation in a $v_t = 0$ state. Additionally all $K$ values above 2 show some obvious perturbations. The three states that lie just above $\nu_{20}$ are $2\nu_{21}$, $2\nu_{13}$ and $\nu_{21} + \nu_{13}$. It has been determined that $\nu_{20}$ interacts weakly with both $2\nu_{21}$ and $2\nu_{13}$ and that $2\nu_{21}$ interacts weakly with $2\nu_{13}$, in spite of their common symmetry and very close proximity. However, all the interactions of $\nu_{21} + \nu_{13}$ appear to be very strong, making assignments of the combination band particularly problematic. The numerous interactions result in wide spread anomalous torsional splittings. These splittings provide valuable insight into the nature of the interactions, however without a reasonable model, assignment of A or E to a torsional component is far from obvious. There remains no reasonable quantum mechanical description of how to proceed with a torsion-rotation-vibration analysis involving large and small amplitude motions. Regardless, everything that can be assigned in the laboratory spectrum can be securely identified in the astronomical spectrum of several sources, suggesting that a solution to this problem is needed. We present what is known and unknown in this quartet of $CH_3CH_2CN$ states.

[a]Daly, Bermúdez, Lopez, Tercero, Pearson, Marcelino, Alonso, and Cernicharo, *Astrophys. J.* (2013) in press.