The Infrared Spectrum of Neutral Sulphur (S I)

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A recent summary (Martin et al. 1990) of the atomic spectrum of neutral sulphur shows that there are still some unknown levels due to unmeasured or unresolved high-lying transitions. A thorough high-resolution survey of the infrared transitions of S I had not been previously done (Kaufman & Martin 1993). New infrared emission spectra have been used to accurately locate many of the missing levels.

A microwave discharge in flowing helium/hydrogen sulphide mixture was used as the emission source. The National Solar Observatory Fourier transform spectrometer was used with calcium fluoride optics and a resolution of 0.005 cm\(^{-1}\) in the 1700 to 10,000 cm\(^{-1}\) region. An impurity spectrum centered at 2100 cm\(^{-1}\), due to the (1,0) vibration-rotation band of CO, provided excellent wavenumber standards. Most of the stronger sulphur lines have estimated absolute errors of less than 0.001 cm\(^{-1}\). Some of the strong sulphur lines also show small isotope shifts due to the 4% abundant \(^{34}\)S. The only other major emission spectra were the vibration-rotation bands of the HS and CO\(_2\) molecules. Spectra of this source were also obtained in the 10,000 to 20,000 cm\(^{-1}\) region, but interference from other band spectra, such as diatomic sulphur, made these spectra less useful. The atomic sulphur lines were completely resolved with widths between 0.015 and 0.06 cm\(^{-1}\) corresponding to a Doppler temperature of 900 K. We have also found that some of the stronger lines in our spectra correspond to some features in the ATMOS solar infrared spectra (Geller 1992) that were not previously identified as due to neutral sulphur.

Analysis of the infrared spectrum was straightforward starting from the known level values (Martin et al. 1990). Most of the narrow lines were assignable to transitions between these levels or a few new levels listed in Table 1. There were a few lines, that appear to be due to atomic sulphur, that could not be assigned. Since there are no ground state transitions in the region of our measurements, it was necessary to assume one such connection to tie our measurements to the ground state. We chose to use \(^3\)S\(_1\) (4\(_s\)) - \(^3\)P\(_2\) (3p\(^4\)) as 55330.811 cm\(^{-1}\). We hope to obtain new UV measurements that will fix the ground and several low-lying states to more accurate values.

Over 470 infrared S I transitions were combined by least squares to yield 58 odd and 54 even levels with a standard deviation of 0.0005 cm\(^{-1}\). A few missing S I levels have been found that were not listed earlier (Martin et al. 1990) and
are given in Table 1. In addition some 5f and 6f multiplets were resolved, but their analysis is still being examined. A complete list of S I lines and levels of greatly improved accuracy will be published elsewhere.

Table 1. Newly located levels (in cm\(^{-1}\)) of S I.

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<th>Energy level</th>
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References