We report the first detection of polarization in the CO bandhead emission at near-infrared wavelengths ($\lambda=2.3$ mm). In this paper we describe the results for two young stellar objects: SSV 13 and DG Tau. The near-infrared polarization ($P \geq 13\%$) of the CO bandhead in both objects is considerably higher than the polarization in their continua. This suggests that, at least in those two objects, the CO emission originates in DISKS, rather than in stellar winds.

It is now twenty years since the first detection of the first overtone bands of CO in the Becklin-Neugebauer (BN) object (Scoville et al. 1979). Possible mechanisms for the excitation of the vibrational states of CO have been described by Scoville, Krotkov & Wang (1980) and by Krotkov, Wang & Scoville (1980). The detection of the CO bandhead in the BN object and further NIR spectroscopy of the same region (Scoville et al. 1983) showed that in order to reproduce the relative band strengths, high vibrational temperatures are required ($\sim 3500$ K). It was also noticed since then (Scoville et al. 1979, 1983), that the CO bandhead emission must be localized within a small radius (a few AU) of the BN object, since the features are seen with the same strength in spectra taken with quite different apertures.

Dozens of young stellar objects (YSOs) have been detected via their CO bandhead either in emission or absorption (Thompson 1985; Geballe & Persson 1987; Carr 1989; Carr & Tokunaga 1992; Carr et al. 1993; Chandler et al. 1993, 1995). All the observations exhibit band strengths which are consistent with excitation temperatures of 2500 - 4000 K. It is still not known how this gas is excited and where it is located, nor has it been possible to study its kinematics. Two possible scenarios have been proposed for the origin of the CO emission: an outflowing wind or a neutral circumstellar disk (see Carr 1989 and references therein). Recent high-resolution infrared spectroscopy in the CO bandhead (Chandler et al. 1993; Chandler, Carlstrom & Scoville 1995; Najita et al. 1996) of YSOs shows more evidence for a “disk” origin for the CO emission, rather than a wind origin. All these recent observations show that the bandhead often exhibits the characteristic shape of emission from a rotating disk (see Najita et al. 1996 and references therein). A contribution from a wind to the CO emission of a rotating disk can be ruled out by the absence of line asymmetries in the NIR spectra. Line asymmetries would be expected due to the occultation the receding flow by an optically thick disk. An additional line asymmetry would be expected if the wind (cooler than the star and disk) would absorb the stellar and disk continuum. These effects have not been observed to date.

The motivation for this work is the increasingly common detection of the CO bandhead emission in YSOs (Carr 1989) since it was first discovered by Scoville et al. (1979). Most YSOs are surrounded by dust envelopes, which scatter not only the continua of young stars but also the radiation originating in the inner regions of their disks (if present). Scatter radiation can be detected as “polarized light”.

Narrow-band polarimetry and centered at 2.3 mm, the first overtone ($\nu=2-0$) of the CO emission, of YSOs could provide perhaps the best method to distinguish between the two possible origins: circumstellar disks or neutral stellar (or disks) winds.

As part of an ongoing observational project at McDonald Observatory SSV 13 DG Tau have been observed at near-infrared wavelengths using the polarimetric near-infrared camera ROKCAM (Colomé & Harvey 1993) of the University of Texas. The CO bandhead emission from both SSV 13 and DG Tau is unresolved with our resolution. Their FWHM are approximately 1.2” (3 pixels). For both objects the polarization measured with the narrow band filter centered in the CO bandhead is much higher than the one obtained using a broader K-band filter. The results are summarized in Table 1. For these two objects the polarimetry provides evidence for a “disk” origin for the CO emitting region, rather than a wind origin. In the latter case we would expect the scattering dust to see a more “isotropic” radiation from the CO gas, locally produced, and in such case, the large values of the polarization ($P \geq 13\%$) are difficult to reproduce.
Table 1. CO and Continuum Polarization

<table>
<thead>
<tr>
<th>Object</th>
<th>Filter</th>
<th>P (± 2 %)</th>
<th>Q (± 3°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSV13</td>
<td>CO bandhead (v=2-0)</td>
<td>16</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>Kw’ (1.9 - 2.4 mm)</td>
<td>5</td>
<td>73</td>
</tr>
<tr>
<td>DG Tau</td>
<td>CO bandhead (v=2-0)</td>
<td>13</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Kw’ (1.9 - 2.4 mm)</td>
<td>6</td>
<td>108</td>
</tr>
</tbody>
</table>

REFERENCES