Detecting Dust Generating Stars

Wolf-Rayets (WR), are a class of evolved stars existing at the brink of super novae. Of the roughly 250 WRs thus far detected, only twenty-three are known dust producers. These stars are special among other dust producers because of the sheer volume of dust each one creates. It is the properties of this dust envelope around these stars that allowed us to begin defining a technique for detecting the dust-producing WRs using an already existing database.

When we began the project, we suspected that the dust-producers would appear different in the near infrared because dust, which forms at temperatures around 2000 K, would absorb light emitted from the star and then re-radiate that energy at wavelengths around two micrometers. This happens to be the range of the 2MASS (2 Micron All-Sky Survey) database. The first step was to identify the location on a color-magnitude diagram for the dust-producing WRs. Each WR and each star within ten arcmin of the WR were then downloaded from the 2MASS database. I wrote a program to search through these lists of stars and compile a new list composed of the target WR and each star within ten arcsec that met our quality requirements. These new lists I plotted on a J-H vs. H-K color diagram, where J=1.25μm, H=1.65μm, and K=2.2μm.

Once all WRs, dust-producing WRs, and a random sample of ~7000 background stars were plotted, the dust-producers appeared to be separating from the other, but there was a large overlap with the random star sample. The next step was to correct for the effects of interstellar extinction on all our sources. For the WRs, I used the values listed in the literature and made the necessary corrections. The random sample of background stars could not be corrected, however; as they were unknown sources. We settled on the Bright Star Catalogue (BSC) because the stars in the catalogue are a relatively short distance away causing interstellar extinction to be negligible in the near infrared bands. This new random sample of stars was downloaded from 2MASS, and was then plotted with the extinction corrected WRs on the same color diagram. This time, we achieved a strong separation for the dust-generating WRs with only a ~5% contamination with the random sample.

As nice as this diagram was, it still had flaws. Those WRs located in the Galactic Center were at the detection threshold of the 2MASS, and confusion with other stars further damaged photometry. Considerable time was taken to identify each WR in the original 2MASS images using finding charts. This proved to eliminate 80% of the Galactic Center population of WRs as either not detected or untrustworthy. I then searched for other deeper, more localized surveys that had J, H, and K photometry for any of the WRs 2MASS could not detect. Those WRs in other surveys had extinction estimates already calculated, but those in 2MASS were still of unknown values. I then searched for and found an extinction contour map for the Galactic Center, which we then used to estimate the extinction for the 2MASS data. Combining all these data points onto the color-diagram, we found that the uncertainties in the extinction were causing a large scatter in those values from the Galactic Center. Because of the uncertain and variable extinction in the Galactic Center, we could not use this plot because our separation criteria depended on the accurate correction of extinction.

The rebirth of the project occurred when I was asked to create a different color-magnitude diagram for the partner Montreal group. I realized I had not attempted to plot differing combinations of the J, H, and K diagrams since the earliest data set when I had decided on the J-H vs. H-K plot. I plotted every combination until I found that for a K vs. J-K plot, the un-extinction corrected dust-generating WRs separated themselves from both the BSC and the earlier random sample. We could then define a separation criteria not based on the interstellar extinction that, in conjunction with the original J-H vs. H-K plot, filtered out 99% of the rest of the stellar population.

Once we had these selection techniques, I began doing a blind search of the Galactic Plane for WRs. Here, we found another problem; we were finding far too many sources (~2500) to be only dust-generating WRs. I began comparing near infrared colors of other known dust producers to our own data to find overlap. One-by-one we eliminated other dust sources as major contaminates, finding each of these having an overlap of ~5% with the exception of extreme carbon stars representing ~20% or our sources. In the end, we were left with nearly 1500 unknown sources concentrated in the Galactic Plane that are either dust embedded or dust generating. We are in the process of locating someone who can take a few low-resolution spectra of a short list of sources we believe are part of this unknown group.