Hands on Spectral Line Project

IRAS 19566+3423

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science preamble

Most stars with progenitor masses of 0.8-8.0 $M_{\odot}$ towards the end of their luminous lives return a large fraction of their mass to interstellar space, in the form of a low-velocity neutral wind. Once this process strips a star down to its degenerate core, photons from the hot surface of its core ionize much of the widely-distributed mass in its wind, to produce a planetary nebula. The OH emission phase of a star is thus restricted to a portion of the time during which a star is losing mass in a dense wind.

Dust grains condense in the outflowing wind. Besides intercepting much of the radiation from the photosphere, which is then reradiated as black-body radiation in the mid-IR, dust grains also protect outflowing molecules against rapid degradation by interstellar UV. Nevertheless radial dilution eventually gives interstellar UV access to the molecules, whereupon in oxygen-rich shells water is degraded first to OH, and then into its atoms. We therefore expect a layer of OH molecules near the outside of the outflowing molecular wind, typically at radii of order 10^16 cm (and **wind travel times of 100-1000 years**). The large radii of thick OH shells thus suggest that systematic changes in their OH masers are likely to require an important fraction of the wind travel-time to accomplish.

19566+3423 project

The velocity range covered by each of the 1612, 1665 and 1667 MHz OH emission lines of the IRAS source 19566+3423 more than doubled (from ~12 km/s to at least 30 km/s) between 1988 and 1999, as Figure 1 shows. In each case the increase in the velocity range is approximately symmetrical with respect to the average emission-velocity, and so is not simply the result of adding a new feature. Arguing by analogy with the usual scenario for OH/IR stars, it would appear that we are witnessing the "turn-on" of masers in 19566+3423, though the short time-scale associated with this process is quite a surprise. As the magnitude of the velocity change is completely unprecedented, we really do not know how the object is likely to develop over time. Our present task is to check whether there has been a change in the velocity range of any of the emission lines over the last two years, to assess whether velocity changes are still occurring: the source may have completed its development in this regard, or it may still be evolving.

observing requirements

The peak intensities in the 1612 and 1665 MHz lines are of order 3 Jy, though much of the emission is in the 50-300 mJy range. These observations need to be made with sufficient sensitivity (~10 mJy), with appropriate bandwidth and observing mode, as well as simultaneously in three different frequencies. Since the object is close to the Arecibo zenith angle limits, the maximum access time on any night is ~100 minutes.

position (1950) 19h 56m 38.1s 34d 23' 20"
lsr velocity -44 km/sec

continuum calibration source

[suggest J2109+355	21h 09m 31.9s	35d 32' 57.6"	1400 MHz	NVSS== 1195.7 mJy	
(not complex in structure:	8.4	4.85	0.365	GHz	
	894	1072	1638	mJy)	position epoch 2000]

You need to prepare a src.list file with the positions and velocities of the sources you intend to observe, to facilitate pointing the telescope

correlator options

You need to consider the correlator hardware available together with the task in hand, before deciding how to specify an appropriate bandwidth for each subcorrelator; one line, and one sense of polarisation per sub correlator.

[8192 lags == 8 subcorrelators; bandwidth is an option for each line]

caution - the Arecibo correlator has digital filters, which implies a loss of ~10% of the nominal bandwidth in roll-off at the edge of the band. This loss is compensated by the excellent flatness of the filter response, which for many kinds of spectral line observations allows simple ON-source scans to be taken, with the baseline being flattened by fitting a polynomial to the baseline.

observing time procedure options

You need to decide how to observe for this project (ie do you want to position switch, or do just ON-source scans), then to establish that a tcl procedure is available to support your choice(s).

You will need to use the L-band wide receiver {lbw}

You should ask for the large gain-tube cal (hcal) == ~30% of system temperature

You should ask for an appropriate front-end filter , being mindful that here are strong radar signals at frequencies below 1.5 GHz, while the L-band receiver is sensitive all the way down to 1 GHz.

SPECTRAL LINE in GENERAL

the observatory's observing manual pages can be viewed at:--

http://www.naic.edu/menuimag/astronomy.htm

use ghostview to leaf through the contents, mark the spectral line pages, then request a printout of the marked pages. There is an APPENDIX section for spectral-line to copy as well.

The attached sheet is a digest of what is needed to get started for the s1529 session

One can get onto the "observer2" workstation from anywhere else in the observatory, via

rlogin observer2 -l dtusr

the rest of the input lines, movement to the program area, etc are as if you were logging on directly at "observer2"

nb need a setup file, for s1529 -> suoh4

can get a listing of this file via

lpr /share/obs4/usr/s1529/suoh4

need a file of sources -> src.list --> add lines to the existing file to suit need
need a procedure file -> s1529.proc --> use src to take 5 one minute records, followed by a 10 sec gain tube ON/OFF

get a log file of the sources observed, their scan numbers, the time they started in s1529.log

analyz is run from the s1529 area; the files present there can be listed with the unix "ls" command, etc.

s1529 -- To observe from "observer2" using s1529.proc, src.list, analyz, etc.

login to "observer2"
    login:- dtusr
    pwd:-
    default through a couple of queries until two windows open

in RHS window - which is for datataking type

```
        datataking cor     ;which starts the correlator program
                           ;brings up correlator window, echo clock, etc
then    gousr              ;to move to general program directory area
        cd  s1529          ;to move to the specific  s1529 observer's area
                           ;*****
        source  suoh4      ;to invoke a preset file of actions that initiates the
                           ;program for observing OH/IR stars in four lines
                           ;with both polarisations
```

Interactive observing proceeds thereafter

To make a 5 minute position-switched observation of WX Psc:_

dosrc wxpsc

To make an ON-source integration of WX Psc, for 7 one minute scans:-

src wxpsc 7
This telescope tcl routine issues an integration request for an ON-source integration, followed by a 10 second gain-tube ON/OFF sequence. src typically takes 6 minutes.

There is a log file attached to the program (s1529.log), that records position changes, scan numbers, doppler factor, the start time of scans, etc.

nb the observing console accepts type ahead. A tcl procedure can be aborted via a control_C

To view data coming into ANALYZ for an existing area [using the BML Package of routines]

in LHS window, of datataking terminal used for data reduction/display, etc that is opened initially type:-

```
gousr
cd   s1529                ;then the first action:- eg
analyz  -u  s1529         ;to open a data processing area
corv2                     ; the only option that works

                          ;To see the results of the first integration
do                        ;to invoke a prepacked routine [[it is editable]],
                          ;that displays 4 sbc (after averaging the two polarisations)
```

useful ANALYZ commands within this library:-

```
ss1            ;to assert the first subcorrelator for display/processing
bm             ;show baseline model (you can change the polynomial order of the fitted
               ;baseline to n;    via    set p n )
cr             ;to invoke the crosshairs, any key to get a readout of its lag position
a b c d:nreg   ;to define an nregion for guiding the zones fitted by a polynomial baseline
bas            ;to remove the baseline, store result to sto/rcl 22
n              ;to move to the next subcorrelator in the row
han            ;to hanning smooth
smo  n         ;to make a running boxcar smooth over n lags
pscan          ;display the next scan number that will be processed
               ;change or direct via    set scan xxxxxxx
pv             ;plot the content of sto/rcl 22 against velocity
```

if one has a series of consecutive spectra to handle

do also stores each incoming, unprocessed spectrum on an internal ANALYZ stack, starting at sto/rcl 30 and incrementing at each successive invocation of "do"

having defined an nreg, a polynomial order (default is 2nd), and a subcorrelator

```
sump           ;sums all profiles on the stack, in inverse proportion to rms**2, display
               ;the resulting baselined spectrum, is left in sto/rcl 22
pv             ;plots against velocity
note           ;annotates spectrum
copy           ;provides a hardcopy from the laser printer
mmi            ;to reinitialize the internal stack (prior to beginning reduction again)

listf do       ;examine the content of   do
```

nb default processing expects position-switched data with 5 subscans as the default
to adjust for an ON-source observing sequence, followed by a gain-tube on/off pair, redefine "pair" via

onlyons pr1:pair

to return to position-switched processing

pair% pr1:pair

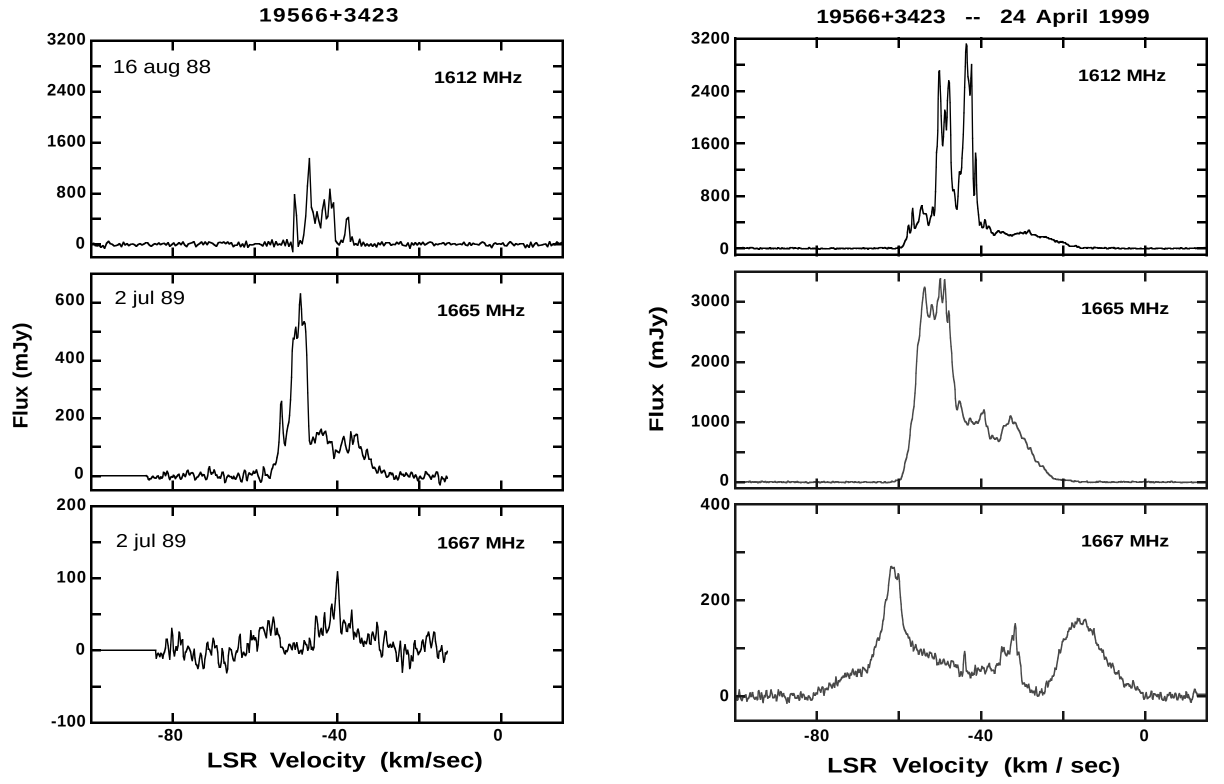

Fig. 1: Arecibo OH spectra of 19566+3423; (a) from 1988-9; (b) from 1999.

Fig. 2: IR fluxes of 19566+3423 with 10 sigma error bars, together with the 226 K black body curve fitted to the IRAS fluxes, and a SED from DUSTY.