Spectral Resolution of SWS AOT 1

Rosario Lorente

30 September 1998

1 Introduction

The S01 instrumental profile was preliminary studied using observations performed on NGC6543 at all four speeds, and on NGC7027 at speed 4. The main assumptions and results are shown in SIDUM. Subsequent measurements on NGC7027 S01 spectra, speeds 1,2,3 and 4, together with the development of a theoretical model of the AOT1 scanning mode have completed the study.

2 Observational AOT 1 Instrumental Profile on NGC7027

The S01 instrumental profile has been measured in each one of the four scanning speeds on a set of four spectra of the Planetary Nebulae NGC7027. The analysis carried out assumes, as in the previous documents, that:

- lines are not resolved by the instrument.
- lines can be fitted by a gaussian over the continuum.

2.1 Results

Table 1 contains the AOT1 resolution, $\lambda/FWHM$, at different speeds, measured in a set of 46 lines of NGC7027. Each resolution value is given with two parameters which are the line-to-continuum intensity and the continuum intensity at the center of the line. These two parameters give an indication on the reliability of the measured resolution, those values with small line to continuum ratio or faint continuum being less reliable. Some pathologic cases are also explained.

In order to avoid misunderstandings where an overlap between AOT bands exists, the band where the line was fitted is also indicated. Notice that this overlap depends on the S01 speed.

The S01 resolution obtained in this study does not differ more than 7% from the preliminary results.

Figures 2 to 5 show the resolution vs. wavelength in each AOT band. The trend is very smooth for each scanning speed and shows an increase of the resolution with wavelength. The scatter is higher at shorter wavelengths because of the weakness of the measured lines. No significant lines were found in band 3E.

Figure 1 shows the ratio between the resolution at different speeds and the resolution at speed 4, the most reliable one. As predicted in the preliminary study carried out on the PNe NGC6543, assuming that it is constant in all the bands, the mean ratio is:

* $\frac{R(1)}{R(4)} \simeq 0.38$
* $\frac{R(2)}{R(4)} \simeq 0.31$
* $\frac{R(3)}{R(4)} \simeq 0.58$

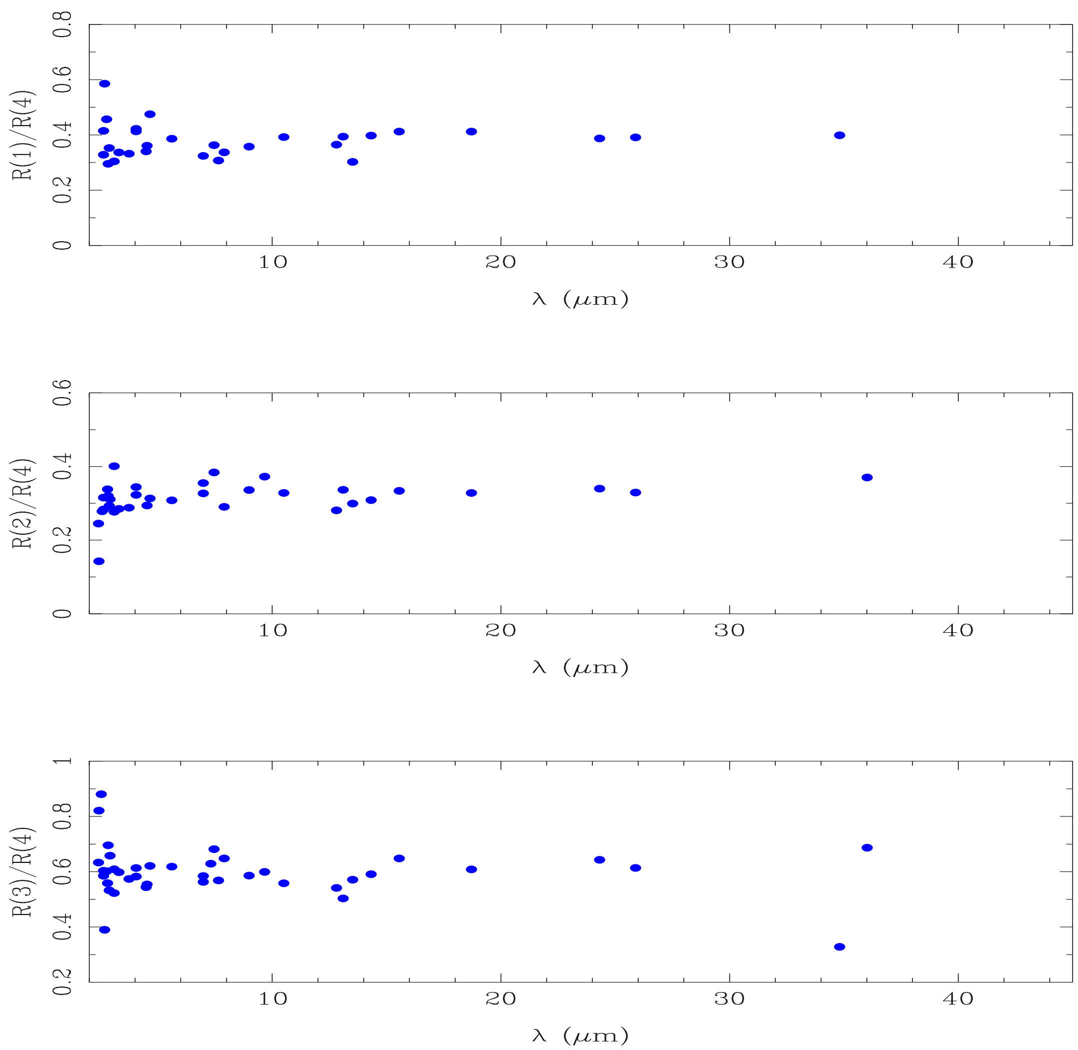

Figure 1: Ratios between observed resolution values at different AOT1 speed.

The most important deviations from this behaviour occur in bands 1A and 1B where the continuum is fainter and the fitting less accurate.

λ	observed $\lambda/FWHM$ on NGC7027											
band 1A	SPEED 1			SPEED 2			SPEED 3			SPEED 4		
	R	L/C	C	R	L/C	C	R	L/C	C	R	L/C	C
2.407				363	0.7	1.5	938	1.8	1.2	1481	3.0	1.2
2.424				[2,3,4]252	0.4	1.6	[2]1450	1.1	1.3	1767	1.5	1.3
2.526							[1,2]1945	1.0	1.2	[1]2209	1.5	1.2
2.564				432	0.5	1.4				1550	1.6	1.2
2.626	570	9.5	2.6	492	6.3	3.4	1047	17.3	2.6	1735	23.8	3.3
band 1B												
2.564										1370	1.3	1.0
2.626	500	10.6	1.4	380	9.1	1.4	704	13.2	1.7	1204	26.7	1.5
2.675	[2]872	0.7	1.5				581	0.8	1.6	1490	1.5	1.6
2.758	[2]533	0.9	1.5				703	1.1	1.7	1168	2.3	1.4
2.803				440	0.8	1.4	728	1.2	1.5	1302	2.1	1.4
2.826	410	1.2	1.9	444	1.1	1.7	964	2.3	1.7	1385	5.0	1.5
2.873	492	1.0	1.7	409	0.8	1.6	743	1.4	1.7	1395	2.9	1.6
2.905				409	0.3	1.6	866	0.4	1.6	1316	0.8	1.6
band 1D												
3.092	476	4.8	2.0	434	4.5	1.8	818	8.0	1.8	1565	11.2	2.4
3.297	[6]497	0.2	19.6	[6]421	0.2	19.1	[6]883	0.5	15.3	[6]1476	0.4	31.4
3.740	949	2.4	3.4	568	2.3	3.1	1076	3.7	3.4	[5]		
band 1E												
3.092				395	3.3	1.5	600	5.6	1.7	986	8.7	1.8
3.297										[6]984	0.0	21.3
3.740	393	1.7	3.4	341	1.4	3.2	679	2.5	3.3	1184	4.1	3.8
4.052	520	12.1	4.2	398	10.0	4.0	717	17.5	4.1	1231	26.3	5.1
band 2A												
4.052	483	10.1	4.3	403	5.6	6.6	718	11.2	5.1	1170	14.0	7.1
4.487	475	17.2	4.9				760	26.7	4.8	1397	38.3	6.3
4.530	521	9.8	7.2	425	9.0	7.2	800	22.5	5.1	1444	28.2	7.1
4.654	677	2.1	6.7	446	1.2	7.9	885	2.7	5.9	1425	5.0	6.2
5.610	696	17.8	20.4	593	21.2	16.9	1037	45.0	12.5	[5]		
band 2B												
5.610	314	15.8	11.5	251	10.3	13.9	503	23.0	12.3	813	27.5	17.1
6.985	337	0.4	45.6	369	0.4	47.4	586	0.6	43.6	1041	1.0	55.2
band 2C												
6.985				387	0.2	61.8	692	0.4	60.7	1184	0.5	70.6
7.318							753	0.2	72.4	1197	0.4	83.4
7.460	359	0.2	79.7	380	0.2	89.9	674	0.4	90.4	989	0.5	103.7
7.653	375	0.7	107.2				694	1.1	120.4	1221	1.5	138.4
7.902	381	0.3	117.8	329	0.3	127.7	733	0.6	128.1	1131	0.7	148.1
8.992	501	1.5	87.1	471	1.2	100.9	821	2.2	95.7	1401	3.3	113.3
9.665				589	0.1	118.7	949	0.1	116.5	1582	0.2	136.1
10.510	667	4.3	163.6	558	4.3	163.9	949	7.3	163.6	1700	9.7	206.2

λ	observed $\lambda/FWHM$ on NGC7027											
band 3A	SPEED 1			SPEED 2			SPEED 3			SPEED 4		
	R	L/C	C	R	L/C	C	R	L/C	C	R	L/C	C
12.813	423	0.5	323.5	326	0.4	325.2	628	0.8	323.3	1160	1.2	337.5
13.102	497	0.2	285.6	425	0.2	282.7	635	0.3	281.4	1261	0.6	277.2
13.521	380	0.2	304.9	376	0.2	307.3	717	0.4	300.7	1256	0.8	290.0
14.321	538	8.2	350.2	418	8.4	297.4	799	15.6	339.2	1353	25.6	329.4
15.555	569	7.4	461.0	461	8.2	375.1	894	12.5	443.2	1380	21.4	381.1
band 3C												
18.713	701	0.5	751.2	558	0.5	709.4	1035	0.9	708.8	1700	1.3	727.9
band 3D												
24.317	387	1.2	1231.8	340	1.1	1208.7	643	2.0	1201.1	999	3.0	1208.1
25.890	430	2.4	1321.5	362	2.2	1301.3	675	3.9	1282.3	1101	5.7	1383.5
band 4												
33.480										1302	0.1	1433.1
34.815	[3,7]693	0.1	1765.3				[2,3,7]570	0.1	1616.5	[7]1738	0.1	1393.1
36.013				515	0.2	1573.7	956	0.3	1575.8	1392	0.5	1357.1

Table 1: AOT 1 resolution measured on NGC7027 for different scanning speeds. The different AOT bands are separated in boxes and are specified in the first column, together with the wavelength of the centre of the measured spectral line. The remaining four sets of columns refer to the resolution at speeds 1, 2, 3 and 4, respectively. Each set includes the resolution, the line-to-continuum ratio and the continuum level of the line.

Some pathologic cases are found mostly in bands 1A and 1B, related with the intrinsic difficulty in the fitting procedure when the line or the continuum is very faint ($\sim 1Jy$):

(1) value of the Resolution which does not follow the smooth trend expected when plotted versus wavelength in an AOT band. See Figures 2 to 5 .

(2) value of the resolution which does not follow the constant ratio between resolutions at different speeds. See Figure 1.

(3) value of the line flux with an inconsistency greater than 20% with respect to the flux of the same line at speed 4 (assuming that this is the best on the basis of a better SNR).

(4) value of the center of the gaussian fit which shows a great displacement with respect to the center of the same line at speed 4.

(5) non-existent line in this AOT band.

(6) PAH emission also present, uncertainty in the continuum level.

(7) strong line, possibly affected by memory effects.

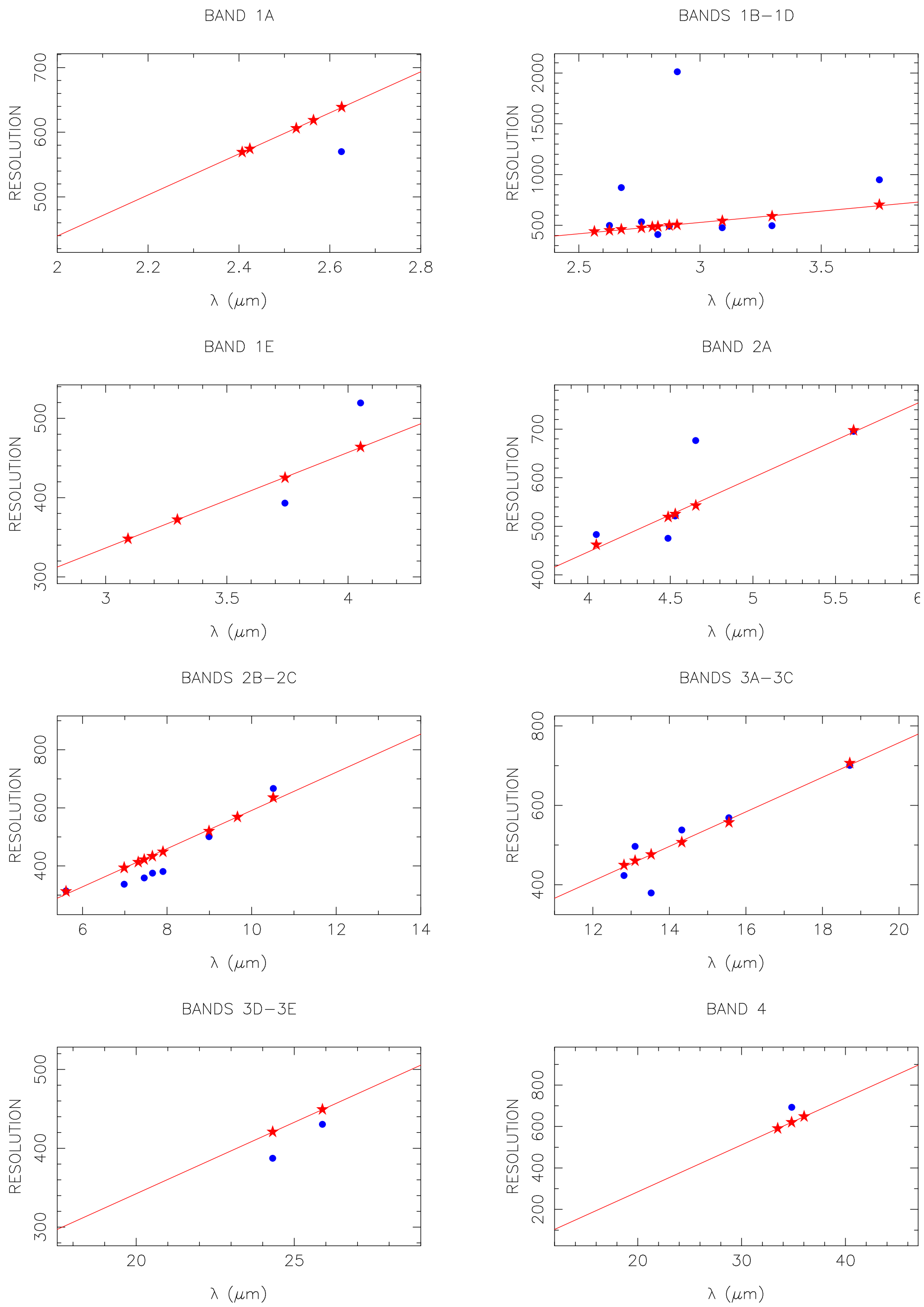

Figure 2: Observed and theoretical resolutions for AOT1 speed 1. Stars correspond to theoretical resolution values and dots to observations. The straight line is the linear fit to the theory. The bands which have a continuous trend in the resolution, that is, which correspond to the same detector block and order, have been plotted in the same pannel.

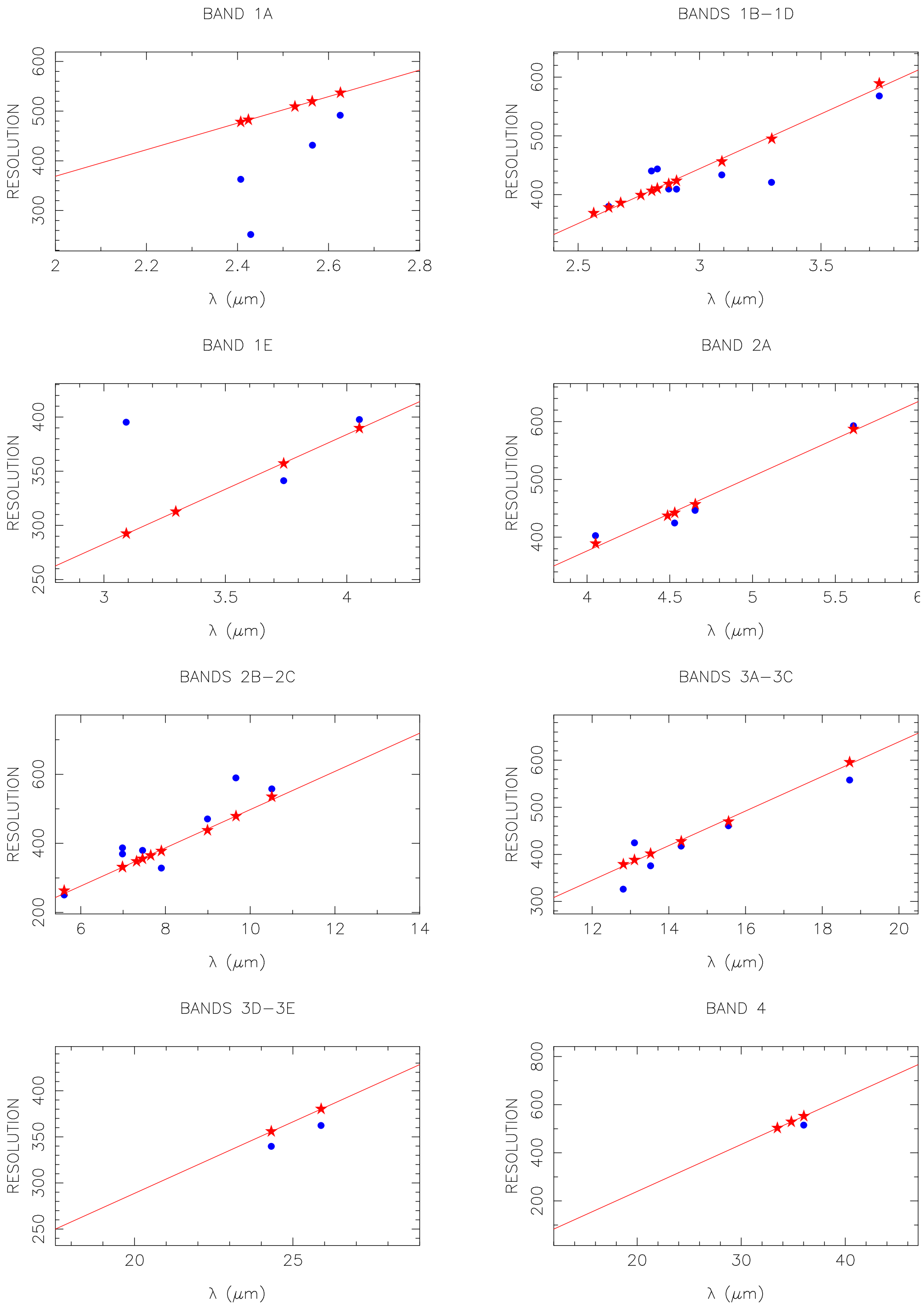

Figure 3: Observed resolutions for AOT1 speed 2. Symbols are as in Figure 2

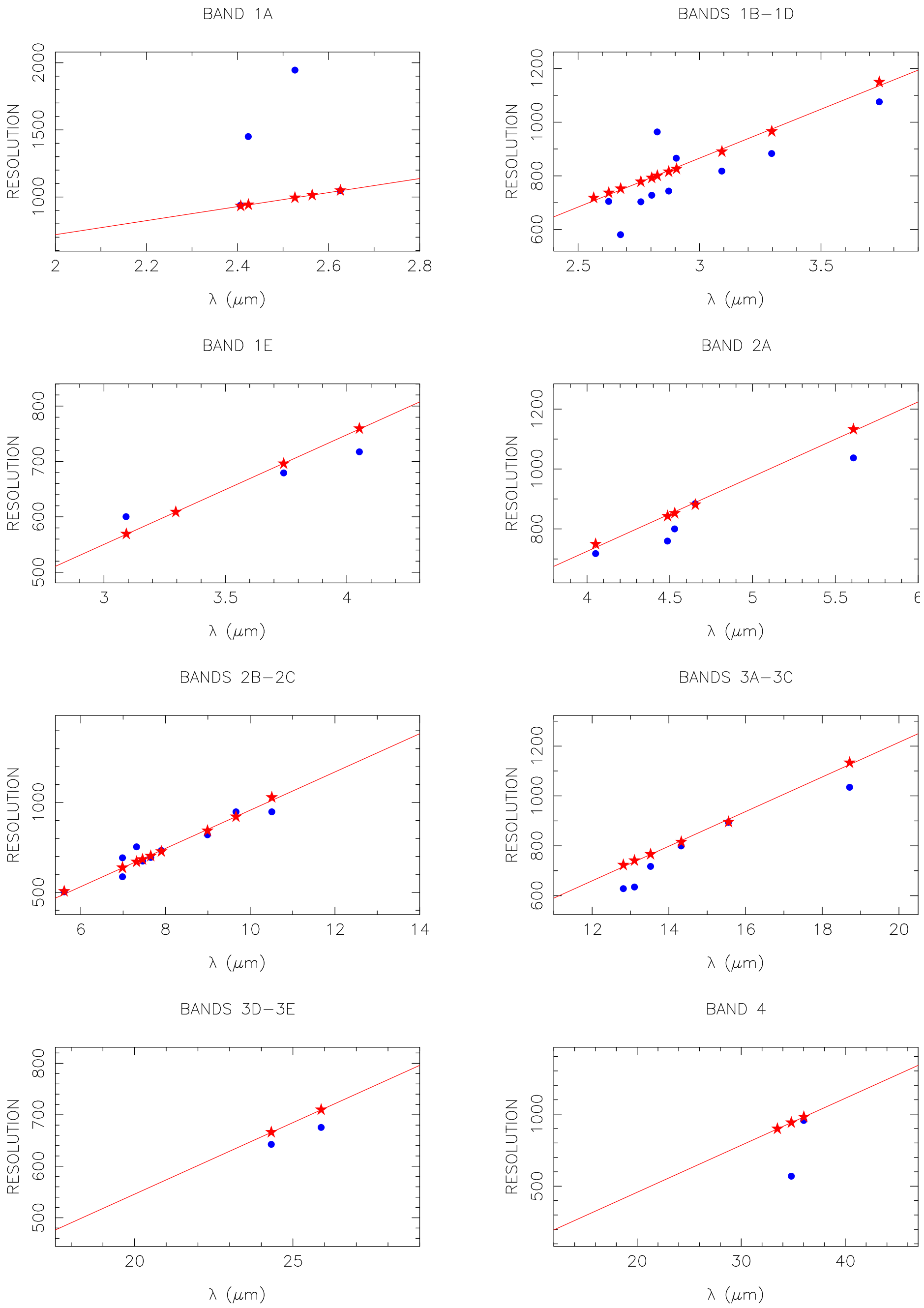

Figure 4: Observed resolutions for AOT1 speed 3. Symbols are as in Figure 2

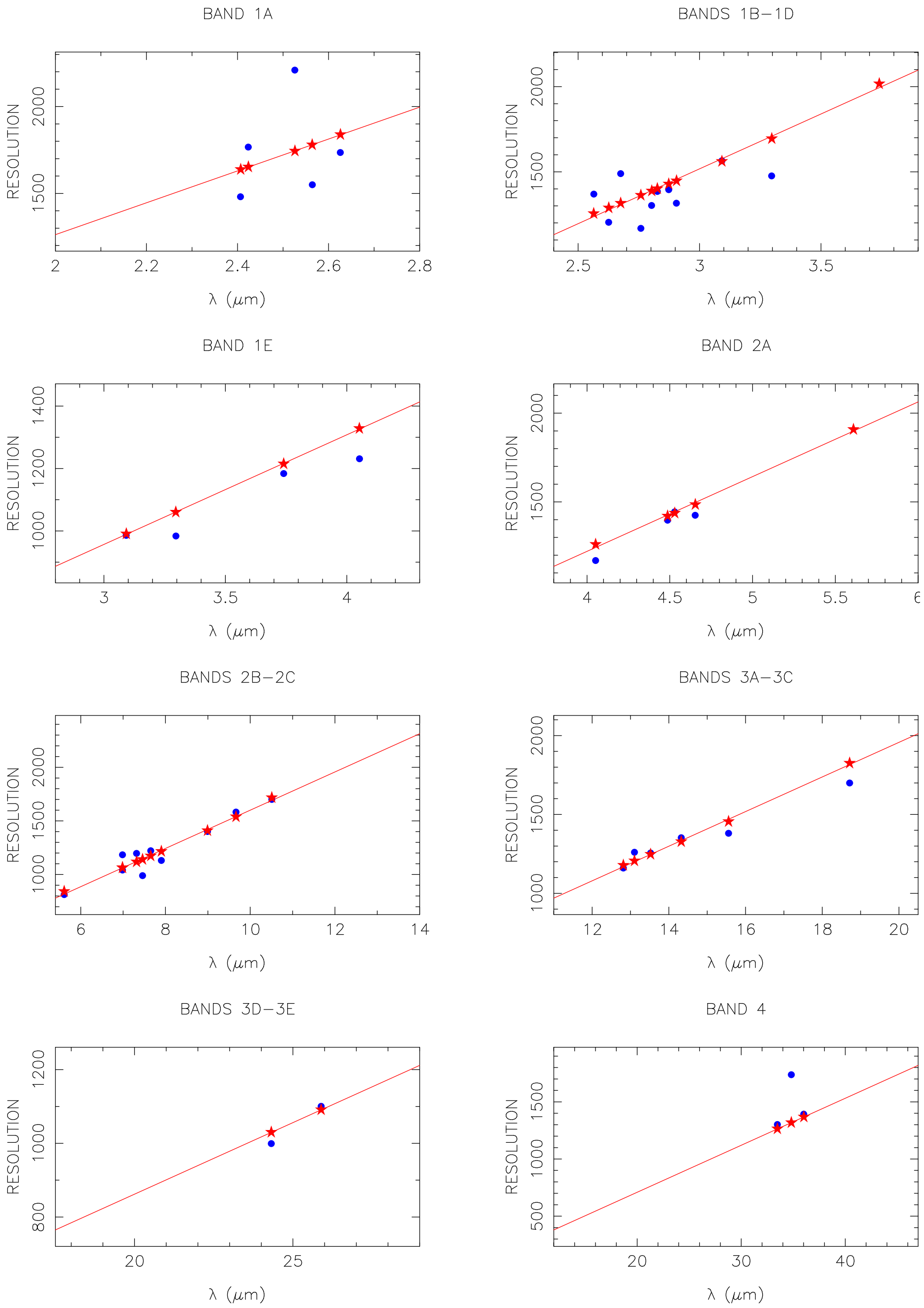

Figure 5: Observed resolutions for AOT1 speed 4. Symbols are as in Figure 2

3 Theoretical AOT 1 profile

The theoretical S01 instrumental profile has been modelled considering that the grating is moving during a reset interval and taking into account the specific parameters for each speed quoted in Table 4.4, Section 4.2.1, SIDUM: time between detectors reset, time between grating movements (dwell time) and stepsize of the scanning mode in grating position units. For simplicity and as a first approach, we have considered that the offset between detectors in an AOT band is such that the signal corresponding to each grating position is seen by at least one detector.

3.1 Results

The simulation of S01 scans gives non-gaussian profiles, as it can be seen in Figure 6, where the gaussian fit to each profile is also plotted. The difference between the FWHM of the theoretical profile and the gaussian fitting is less that 10% at worst cases. The most extreme case correspond to scanning speed 1 for SW section. This moduled IP is due to the fact that the range of grating scanner positions covered by a speed 1 reset interval is wider than the incoming gaussian ($FWHM(AOT2) = 3$ grating scanner position at short wavelengths).

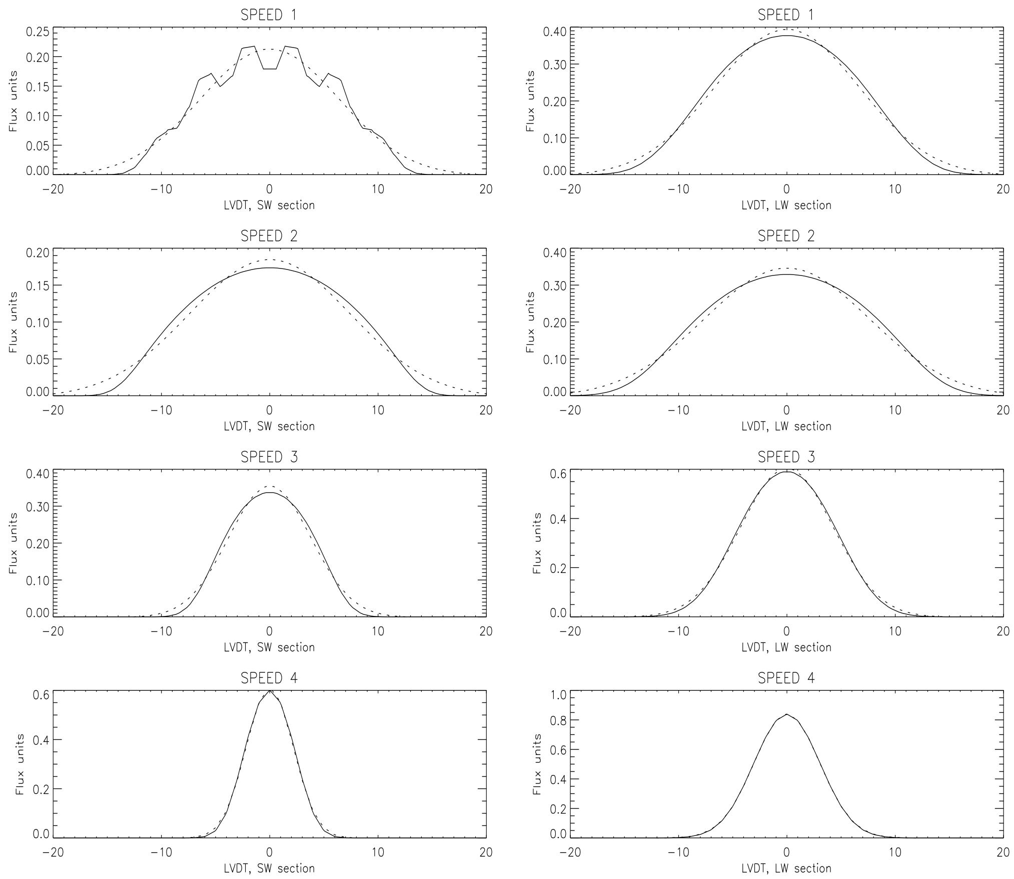

Figure 6: Theoretical profiles (full line) and gaussian fitting to them (dashed line) for each AOT1 scanning speed and for two different widths of the intrinsic incoming profile, corresponding to SW (left panels) and LW (right panel) sections.

3.2 Conclusions

The FWHM of the gaussian fitting to the theoretical profiles have been considered for the computation of the resolution quoted on Table 2. These values agree very well with the observed ones (see Figures 2 to 5) within the uncertainties due to the spectral noise in NGC7027 spectra.

On the other hand, the assumption that there is a constant ratio between the resolution at different scanning speeds is not valid anymore, as it can be seen in Figure 7, because not only the width of the profiles are different, but also their intrinsic shape, due to the different width of the intrinsic profile relative to the scanning mode.

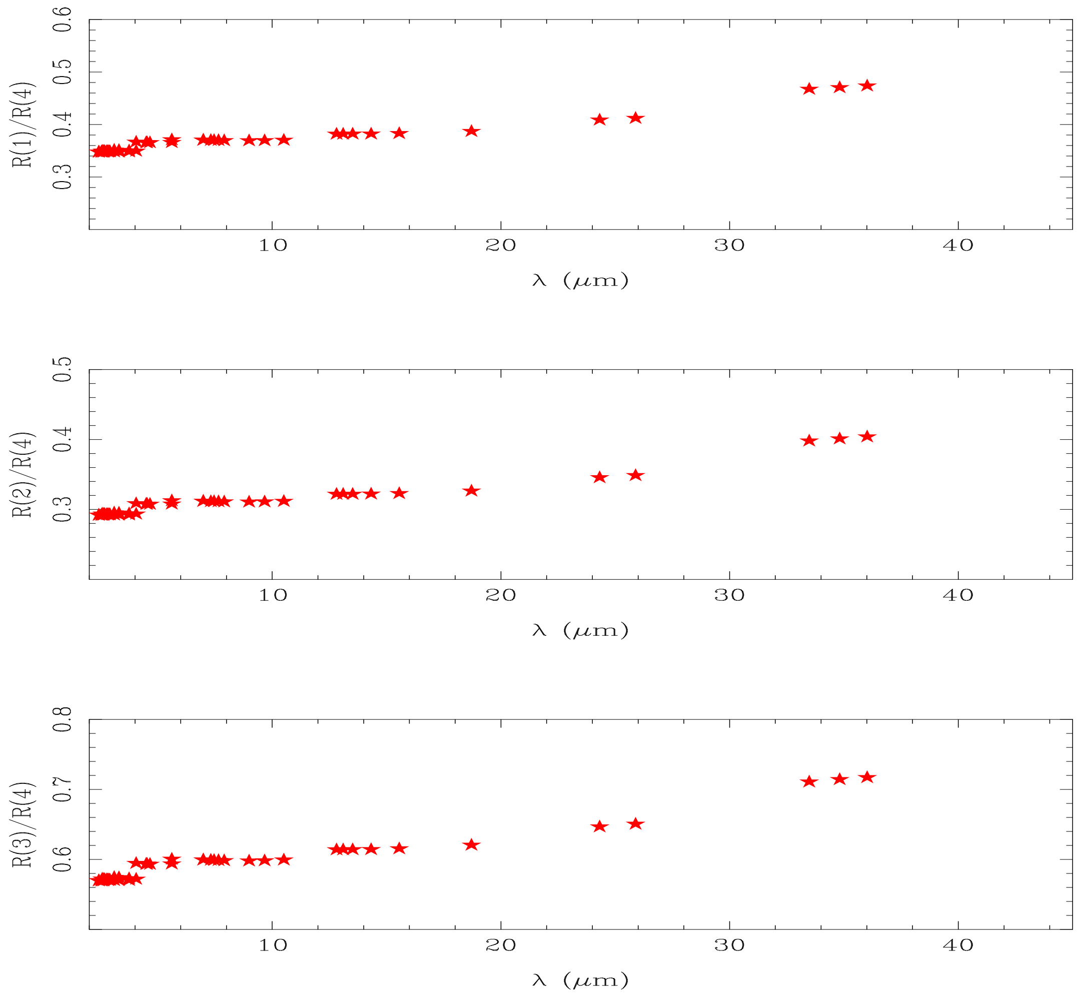

Figure 7: Ratios between theoretical resolution values at different AOT1 speed.

λ	theoretical $\lambda/FWHM$			
band 1A	SPEED 1	SPEED 2	SPEED 3	SPEED 4
2.407	540	465	911	1606
2.424	545	469	919	1621
2.526	575	495	970	1711
2.564	587	506	990	1746
2.626	606	522	1022	1804
band 1B				
2.564	416	358	701	1232
2.626	426	368	719	1265
2.675	435	375	734	1291
2.758	450	388	760	1337
2.803	459	395	773	1362
2.826	463	399	781	1375
2.873	472	407	796	1402
2.905	478	412	806	1420
band 1D				
3.092	515	444	869	1532
3.297	559	482	943	1663
3.740	665	573	1122	1979
band 1E				
3.092	330	285	556	972
3.297	353	304	594	1040
3.740	403	348	679	1193
4.052	440	379	742	1303
band 2A				
4.052	439	378	732	1240
4.487	493	425	823	1397
4.530	499	430	833	1413
4.654	515	445	861	1460
5.610	663	571	1107	1876
band 2B				
5.610	296	256	494	828
6.985	374	322	622	1045
band 2C				
6.985	373	322	622	1045
7.318	392	338	654	1099
7.460	400	345	667	1122
7.653	411	355	686	1153
7.902	426	368	710	1195
8.992	494	426	823	1386
9.665	540	466	899	1514
10.510	603	520	1005	1688

λ	theoretical $\lambda/FWHM$			
band 3A	SPEED 1	SPEED 2	SPEED 3	SPEED 4
12.813	426	369	707	1160
13.102	437	378	724	1187
13.521	452	391	749	1228
14.321	481	416	797	1307
15.555	528	460	875	1433
band 3C				
18.713	670	580	1108	1799
band 3D				
24.317	400	347	652	1017
25.890	427	370	695	1077
band 4				
33.480	562	490	881	1252
34.815	591	515	924	1306
36.013	618	538	963	1356

Table 2: AOT 1 theoretical resolution at different wavelengths and scanning speeds. First column quotes the wavelenths separated by AOT bands. The four remaining columns refer to resolution at AOT1 speed 1, 2, 3 and 4.