The 2015B Report

September 30, 2015

The DIVING^{3D} project: Deep IFS View of Nuclei of Galaxies

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Executive Summary

This is the 2015A report of the LLP: DIVING^{3D}- Deep IFS View of Nuclei of Galaxies. We will present the developments made in the period of 2015A.

First it should be noted that this LLP started formally in 2014A, but includes many objects from previous smaller projects. Therefore one should keep in mind that it has an "evolving strategy" of development.

We identified an additional problem related to the new Hamamatsu CCD installed in GMOS south. This makes the fingerprint removal more complex (but still possible).

The XVII Advanced School of Astrophysics will be on "3D Spectroscopy and Spectral Synthesis", well focused on the two Brazilian LPs.

We provide a brief summary of the observation and status of reduction/analysis of each sample.

In addition we provide comments on the referee remarks.

Finally, we provide four appendices.

Introduction

The DIVING^{3D} Project (Deep IFS View of Nuclei of Galaxies) is a survey of 170 galaxies that satisfy the following criteria: B<12.0, $\delta<0^\circ$ and $|b|>15^\circ$ (11 galaxies classified as Sm/Im were excluded as they do not show any nucleus in the 2MASS images). 29 of these galaxies have already some type of nuclear activity reported in the NED (NASA Extragalactic Database).

This survey is distinct of the northern well known Palomar Survey (Ho et al, 1997). The main differences are that we have a better spatial resolution than Palomar Survey, the usage of 2D spectroscopy (they analyzed long slit spectra) and the fact the we are using an 8m telescope (Palomar is a 5m telescope).

The study started formally 1.5 years ago; however it benefits from previous observations of many objects.

An additional technical problem: the new CCD detector

We identified an additional problem in the data reduction. The new CCD Hamamatsu replaced the old one in Gemini South. This was done to improve the fringing problem in the red. However it also changed the fingerprint pattern, for unknown reasons. The fingerprint became more complicated and more complex to be extracted.

Observational strategy and current (2015B) degree of completion

These sub-samples will be observed according to the following priority – the degree of completion is also shown:

Observational strategy

Priority	*Completion degree*			
	14A	*14B*	*15A*	*15B*
	17 hs	*17 hs*	*21hs*	*21.5 hs*
1 – High –mass ETGs	*100%*	*100%*	*100%*	*100%*
2 – Bright (B<11.0) Mini-DIVING^{3D}		*67%*	*100%*	*100%*
3 – Low-mass ETGs	*7%*	*13%*	*46%*	*87%*
4 – Milky Way twins	*22%*	*35%*	*48%*	*52%*
5 – Early type spirals	*8%*	*11%*	*17%*	*31%*
6 – Late type spirals	*16%*	*22%*	*35%*	*37%*
Total	*29%*	*35%*	*46%*	*59%*

	Observed %	*reduced% (in analysis)*
1 – High –mass ETGs	*100%*	*100%*
2 – Bright (B<11.0) Mini-DIVING^{3D}	*100%*	*70%*
3 – Low-mass ETGs	*87%*	*10%*
4 – Milky Way twins	*52%*	*22%*
5 – Early type spirals	*31%*	*10%*
6 – Late type spirals	*37%*	*16%*
Total	*59%*	*41%*

The XVII Advanced School in Astrophysics

We are promoting the XVII Advanced School in Astrophysics in the areas of the two LP progams being conducted in Brazil: **3D Spectroscopy and Spectral Synthesis**

The lecture topics will be:

Lecture I –Active and non-active galactic nuclei in the NIR (Adaptive optics) – Richard Davies
Lecture II - Science from SAURON and ATLAS3D – Michele Cappellari
Lecture III – Science from CALIFA – Sebastian Sanchez
Lecture IV - Spectral Models - Guy Worthey
Lecture V – Science with Fabry-Perot - Philippe Amram

In addition there will be individual review talks (80+10 min) by Brazilians:
Cid Fernandes: Spectral fitting techniques
Thaisa Storchi-Bergmann: Feeding and feedback in AGN

Invited talks (40+5 min):
Claudia Mendes de Oliveira: BTFI Fabry-Perot spectrograph & FP+SAM
Paula Coelho: Alfa enhancement in spectral libraries
Rogério Riffel: Spectral synthesis in the NIR
Rogemar Riffel: 3D spectroscopy in the optical and NIR
Roberto Menezes:Treatment procedures for optical and NIR data cubes
Tiago Ricci: Long Program: DIVING3D- Deep IFS View of Nuclei of Galaxies (optical IFU)
Alberto Ardila: The coronal line region
Eduardo Telles: Extragalactic H II regions

Coordinator: João E. Steiner

Publications since the 2015A report

Since the 2015A report, one paper was published:

Ricci, T. V.; Steiner, J. E.; Menezes, R. B. 2015 MNRAS 451, 3728
IFU spectroscopy of 10 early-type galactic nuclei - III. Properties of the circumnuclear gas emission

Ricci, T. V.; Steiner, J. E.; Giansante, L. 2015 A&A 576, 58
A hot bubble at the centre of M81

Menezes, R.B., da Silva, P., Ricci, T.V., Steiner, J. E. & May, D., 2015 MNRAS 450, 369
A treatment procedure for VLT/SINFONI data cubes: application to NGC 5643

Menezes, R. B. & Steiner, J. E. 2015 Astrophysical Journal 808, 27
The molecular H2 emission and the stellar kinematics of the nuclear region of the Sombrero Galaxy.

Since 2015A, the following paper was accepted for publication:

May, D., Steiner, J. E., Ricci, T.V., Menezes, R.B, & Andrade, I.S. MNRAS in press.
Digging process in NGC 6951: the inclined molecular disk bumped by the outflow

The following papers were submitted for publication:

The off-centered Seyfert-like compact emission in the nuclear region of NGC 3621
R. B. Menezes, J. E. Steiner and Patrícia da Silva
Submitted for publication in the Astrophysical Journal.

The emission-line regions in the nucleus of NGC 1313 probed with GMOS-IFU: Wolf-Rayet stars and a B[e]/LBV candidate
R. B. Menezes and J. E. Steiner submitted to MNRAS

IFU spectroscopy of 10 early-type galactic nuclei - IV. Properties of stellar kinematics.
Ricci, T. V., Steiner, J. E. & Menezes, R. B. submited for publication to the MNRAS.

We mention these papers as they have taken significant efforts from the group and are based on data taken previously to the start of the DIVING3D Survey. The coming papers will be increasingly related to the DIVING3D project.

Comments to the referee remarks

Para o próximo relatório, a NTAC faz as seguintes recomendações:

- Ainda falta a descrição da participação de membros da equipe que aparecem na lista de co-autores;

De fato deve haver um equívoco aqui uma vez que isto foi descrito no último relatório. Por completeza, repetimos o que consta lá:

Os co-Is tem as seguintes funções:

1- Roberto Menezes: redução, processamento e análise dos objetos que constam do projeto de pós-doutorado dele (amostra de ETGs e Sc-Sc).

2- Tiago Ricci: redução e processamento e análise dos objetos que constam do projeto de pós-doutorado dele (amostra complete de ETGs massivas).

3- Roberto Cid Fernandes, Natália do Vale e André Amorin: Nova síntese espectral e responsabilidade pelas publicações relacionadas à arqueologia estelar.

4- Paula Coelho: análise dos dados e modelos espectrais referentes a alfa-enhancement.

Quanto a trabalhos de dissertações e teses, estamos com os seguintes alunos:

1- Inaiara Andrade, doutorado (IAG/USP; orientador Joao Steiner): Estudo da região central de galáxias S0 ativas e inativas.

2- Patrícia Silva, mestrado (IAG/USP; orientador Joao Steiner): Estudo dos núcleos de galáxias gêmeas da Via Láctea.

3- Maiara S. Carvalho, doutorado (UFSC; orientador Cid Fernandes) – Arqueologia estelar da mini-amostra estatisticamente completa de galáxias com B<11.0 do hemisfério sul.

- Além da inclusão do percentual de dados já coletados em cada sub-amostra, também recomendamos a inclusão do status dos dados, incluindo o percentual de dados reduzidos, analisados, em análise, publicados, etc...

Observational strategy

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	14A	14B	15A	15B
	17 hs	17 hs	21hs	21.5 hs
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- De acordo com a lista de publicações fica claro que os autores ainda estão dedicando parte do tempo na análise de objetos observados anteriormente e não relacionados ao LP (dados de gaveta). Estes trabalhos, embora referem-se a objetos não incluídos no LP, servem como base para o futuros trabalhos oriundos do LP. Recomenda-se que possíveis trabalhos em andamento sejam levados em paralelo ao LP, mas que a prioridade seja dada a análise dos objetos observados na execução do L.

Sem dúvida ainda foram e estão sendo publicados trabalhos relacionados a observações anteriores ao início do LP.

- Seria preferível evitar a publicação de um paper por galáxia, uma vez que isso dilui o impacto do survey. Recomendamos que os resultados intermediários sejam publicados, mas que estes não sejam limitados a uma galáxia por vez.

Concordamos em parte. No projeto que antecedeu o LP, voltado a estudar 10 Galáxias ETG massivas, fizemos análises das 10 galáxias enfocando distintos aspectos globais de cada vez. Isso não impediu a publicação de objetos individuais, que merecessem publicações rápidas. Aliás, essa recomendação foi feita pelo próprio NTAC em semestres anteriores.

Concordamos que precisamos publicar análises estatísticas de subamostras que já estejam completas. Estamos iniciando esses papers, enfocando aspectos da sub-amostra de ETGs massivas.

Appendix A. Relevant publications

A1 - Publications by our group involving objects from the DIVING^{3D} Project, observed with the Gemini telescopes GMOS IFU:

Menezes, R. B. 2012 - PhD Thesis – Universidade de São Paulo

Ricci, T, V 2013 - PhD Thesis -Universidade de São Paulo

Menezes, R. B., Steiner, J. E., Ricci, T. V. 2013 Ap J 765, L40
Collimation and Scattering of the Active Galactic Nucleus Emission in the Sombrero Galaxy

Ricci, T. V., Steiner, J. E. & Menezes, R. B. 2014a MNRAS 440, 2429 – Paper I
Integral field unit spectroscopy of 10 early-type galactic nuclei - I. Principal component analysis Tomography and nuclear activity

Ricci, T. V., Steiner, J. E. & Menezes, R. B. 2014b MNRAS 440, 2442 – Paper II
IFU spectroscopy of 10 early-type galactic nuclei - II. Nuclear emission line properties
Ricci, T. V.; Steiner, J. E.; Menezes, R. B. 2015 MNRAS 447, 1504
Erratum: IFU spectroscopy of 10 early-type galactic nuclei - II. Nuclear emission line properties

Menezes, R. B., Steiner, J. E. & Ricci, T. V. 2014 Ap J Lett 796, L13
An off-centered active galactic nucleus in NGC 3115

Ricci, T. V.; Steiner, J. E.; Menezes, R. B. 2015 MNRAS 451, 3728
IFU spectroscopy of 10 early-type galactic nuclei - III. Properties of the circumnuclear gas emission

A2 - Publications involving observations with the Gemini telescopes IFUs that are related to the project in terms of methodology

Steiner, J. E., Menezes, R. B., Ricci, T. V. & Oliveira, A. S. 2009, MNRAS, 395, 64
PCA Tomography: how to extract information from data cubes

Steiner, J. E., Menezes, R. B., Ricci, T. V. & Oliveira, A. S. 2009, MNRAS 396, 788
Mapping low- and high-density clouds in astrophysical nebulae by imaging forbidden line emission

Ricci, T. V., Steiner, J. E. & Menezes, R. B. 2011, ApJ, 734, L10
NGC 7097: The Active Galactic Nucleus and its Mirror, Revealed by Principal Component Analysis Tomography

Menezes, R. B., Steiner, J. E. & Ricci, T. V. 2013 Ap J 762, L29
Discovery of an Halpha Emitting Disk around the Supermassive Black Hole of M31

Menezes, R. B., Steiner, J. E. & Ricci, T. V. 2014, MNRAS 438, 2597
A treatment procedure for Gemini North/NIFS data cubes: application to NGC 4151

Ricci, T. V.; Steiner, J. E.; Giansante, L. 2015 A&A 576, 58
A hot bubble at the centre of M81

May, D., Steiner, J. E., Ricci, T.V., Menezes, R.B, & Andrade, I.S. MNRAS in press.

Digging process in NGC 6951: the inclined molecular disk bumped by the outflow

A3 - Other publications based on IFU data cubes (not related to the DIVING3D Survey)

Oliveira, A. S.; Steiner, J. E.; Ricci, T. V.; Menezes, R. B.; Borges, B. W. 2010 A&A 517, L5
Optical identification of the transient supersoft X-ray source RX J0527.8-6954, in the LMC

Steiner, J. E.; Menezes, R. B.; Amorim, Daniel 2013, MNRAS 431, 2789
Identification of a high-velocity compact nebular filament 2.2 arcsec south of the Galactic Centre

Menezes, R.B., da Silva, P., Ricci, T.V., Steiner, J. E. & May, D., 2015 MNRAS 450, 369
A treatment procedure for VLT/SINFONI data cubes: application to NGC 5643

Menezes, R. B. & Steiner, J. E. 2015 Astrophysical Journal 808, 27
The molecular H2 emission and the stellar kinematics of the nuclear region of the Sombrero Galaxy.

Appendix B:

The Legacy strategy

Our commitment is to deliver the data to the Brazilian Astronomical Community. The idea is to give access to our community not only to the raw data (available after 1 year anyway) but also the reduced and the processed data. For this reason we will deliver two datacubes for each galaxy:

A – One data-cube with all spectra:

- Calibrated in wavelength
- Calibrated in flux
- Corrected for the differential atmospheric refraction (DAR).
- Fingerprint removed
- High frequency spatial noise remove with Butterworth filter

B – One additional cube will be available to the community with the additional data processing:

- Richardson-Lucy deconvolution

The data will be located in the projects' site ("DIVING3D" in CLOUD-USP) and can be accessed by any Brazilian scientist or student with a password provided under request. The password must be strictly personal and the data cannot be transferred to non Brazilian astronomers.

This plan was announced the 2015 SAB meeting.

Appendix C: the galaxies of each subsample and their status

Notes:

In the second column is the semester the object was observed.

Follows the initial of the person that has reduced/snalysed the data according to:

:R = Roberto Menezes; T = Tiago Ricci; P = Patrícia Silva; I = Inaiara Andrade.

1 - The sub-sample of high-mass (σ>200 km/s) ETGs

Name	*Sem./*	*Type*	*B*	*d*	*MksT*	*gr/clust*	*AddObs*
	Red.	*NED*	*mag*	*Mpc*	*mag*		
Ellipticals							
NGC 1316	13B/R	E4	9.6	20	-26.29 SAB0^0(s)	Forn A	SINFONI; ACS/WFPC2
NGC 1549	13B/R	E0-1	10.76	16		Dor gr	
NGC 1399	08B/T	cD	10.79	18	-25.29	Forn cl	SINFONI; ACS/WFPC2
NGC 3923	13A/T	E4-5	10.91	21			ACS
NGC 1407	13B/R	E0	10.93	23	-25.87	Erid cl	ACS
NGC 3585	13A/T	E6	10.93	18			ACS/WFPC2
IC 1459	08B/T	E3-4	10.96	27	-25.51		WFPC2
NGC 1404	08B/T	E1	11.04	19	-24.49	Forn cl	ACS/WFPC2
NGC 720	13B/T	E5	11.15	24			
NGC 1395	13B/R	E2	11.18	21			
NGC 584	13B/T	E4	11.2	20			WFPC2
NGC 7507	13B/T	E0	11.43	22			
NGC 3557	13A/T	E3	11.46	37			WFPC2
NGC 1052	13B/T	E4	11.53	19			NIFS; ACS/WFPC2
IC 4296	13A/T	E	11.58	51		Gr(30)	ACS/WFPC2
NGC 4696	13A/T	cDpec	11.59	38		Cen cl	ACS/WFPC2
NGC 3962	13A/T	E1	11.66	31			
NGC 5018	13A/T	E3?	11.71	38			WFPC2
NGC 2974	13A/T	E4	11.78	25			WFPC2
NGC 6868	13A/T	E2	11.83	32			
NGC 4105	13A/T	E3	11.88	28			
NGC 5044	13A/T	E0	11.92	35			WFPC2
NGC 3904	13A/T	E2-3?	11.95	25			
NGC 1700	13B/T	E4	11.96	41			WFPC2
S0s							
NGC 3115	13A/R	S0^-	9.98	10.2	-24.03		ACS/WFPC2
NGC 1380	08B/T	SA0	11.1	19	-24.32	Forn cl	ACS/WFPC2
NGC 1574	13B/T	SA0^-(s)?	11.19	19		Dor gr	WFPC2
NGC 2784	13A/T	SA0^0(s)?	11.21	8.5			WFPC2
NGC 1332	13B/T	S0^-?(s)	11.24	20	-24.73	Erid cl	SINFONI; WFPC2
NGC 5101	13A/T	(R)SB0/a(rs)	11.58	27			
NGC 2217	13B/T	(R)SB0+(rs)	11.59	19			
NGC 7049	13A/T	SA0^0(s)	11.64	28			ACS

2 - The sub-sample of low-mass (σ<200 km/s) ETGs

Name	*Sem/*	*Type*	*B*	*d*	*group/clust*
	Red	*NED*	*mag*	*Mpc*	

Ellipticals							
NGC 5128	15A/R	S0 pec	7.89	3.7	-24.34	Cen A	SINFONI
NGC 4697	14A/R	E6	10.11	12.3			
NGC 1344	15B	E5	11.28	18.7		Erid cl	
NGC 5061	15A	E0	11.35	25.6			
NGC 7144	15B	E0	11.79	25.5			
NGC 0596		cD pec?	11.88	21.5			
NGC 1427		cD	11.94	19.4		Erid cl	
IC 5328		E4	11.95	34.7			
S0s							
NGC 1291	14B/I	(R)SB0/a(s)	9.42	8.6			
NGC 1553	14B/R	SA0^0(r)	10.42	15.1		Dor gr	
NGC 5102	15A /R	SA0^-	10.64	18.8			SINFONI?
NGC 4753	15A /I	I0	10.85	16.9		Virgo cl	
NGC 0936	15A/R	SB0^+(rs)	11.19	20.7			
NGC 4546	08A/T	SB0^-(s)?	11.3	18.1			WFPC2
NGC 1326	15B/I	(R)SB0^+(r)	11.34	17.0			
NGC 6684	15A /I	(R')SB0^0(s)	11.34	12.4			
NGC 1302	15B	(R)SB0/a(r)	11.38	20			
IC 5267	15A	SA0/a(s)	11.39	26.1			
NGC 4856		*SB0/a(s)*	*11.4*	*21.1*	*(Não observável; 15A)*		*SOAR?*
NGC 4958	15A?	SB0(r)? e-o	11.48	18.5			
NGC 1543	15B	(R)SB0^0(s)	11.49	17.2		Dor gr	
NGC 1201	15B	SA0^0(r)?	11.56	20.4			
NGC 1537	15B	SAB0^- pec?	11.62	18.5			
NGC 1527	15B	SAB0^-(r)?	11.7	16.6			
NGC 1411	15B	SA0^-(r)?	11.7	15.5			
NGC 4691	15A	(R)SB0/a(s) p	11.7	22.5			
NGC 1533	15B	SB0^-	11.71	18.4		Dor gr	
NGC 4984	*15A*	*(R)SAB0^+(rs)*	*11.71*	*21.3*	*to be observed!*		
NGC 1387	15B	SAB0^-(s)	11.83	17.2		Erid cl	
NGC 1947	15B	S0^- pec	11.86	16.3			

3 - The sub-sample of early spiral galaxies (Sa-Sb)

Name		*Type*	*B(T)*	*d (Mpc)*	*MksT*		
		NED	*mag*	*Mpc*			
M 104	10B/R	SA(s)a e-on	9.28	10.4	-25.36		NIFS; ACS/WFPC2
NGC 1068 ??	/R	(R)SA(rs)b	9.55	13.5	-24.66		NIFS; SINFONI
NGC 1097	15B/Thai	SB(s)b	10.16	20.0			
NGC 1365	14B/	SB(s)b	10.21	17.9		Forn cl	
NGC 4699	13A/T	SAB(rs)b	10.44	24.7			
NGC 1398	15B/	(R')SB(r)a	10.6	21.0		Erid cl	
NGC 1433	15B/	(R')SB(r)ab	10.68	10.0			
NGC 1808	15B/	(R)SAB(s)a	10.7	11.5			

NGC 1672	15B/	SB(s)b	11.03	14.5		Dor gr	
NGC 7213	15A/Thai	SA(s)a?	11.18	22			15A
NGC 7410	15A /	SB(s)a	11.3	20.1			15A
NGC 1617	/	SB(s)a	11.37	13.4		Dor gr	
NGC 1512	/	SB(r)a	11.38	12.3			
NGC 1350	/	(R')SB(r)ab	11.4	20.9		Erid cl	
NGC 7552	/	(R')SB(s)ab	11.4	17.1			
NGC 7582	/T	(R')SB(s)ab	11.46	20.6			SINFONI?
NGC 1371	/	SAB(rs)a	11.5	23.2		Erid cl	
NGC 1532	/	SB(s)b pec e-on	11.53	17.0		Forn cl	
NGC 7606	/	SA(s)b	11.55	31.5			
NGC 7727	/	SAB(s)a pec	11.55	23.3			
NGC 1425	/	SA(s)b	11.6	21.3		Forn cl	
NGC 1964	/	SAB(s)b	11.6	21.4			
NGC 0210	/	SAB(s)b	11.65	21.0			
NGC 4593	/	(R)SB(rs)b	11.72	33.9			
NGC 5792	/	SB(rs)b	11.72	24.4			
NGC 0150	/	SB(rs)b?	11.75	21.0			
NGC 7496	/	SB(s)b	11.78	15.0			
NGC 0986	/	SB(rs)ab	11.8	17.1			
NGC 7723	/	SB(r)b	11.85	27.4			
NGC 0779	/	SAB(r)b	11.86	17.7			
NGC 3223	/	SA(s)b	11.88	33.4			
NGC 4818	/	SAB(rs)ab pec?	11.89	20.0			
NGC 4941	/	(R)SAB(r)ab?	11.9	18.2			
NGC 4995	/	SAB(rs)b	11.9	28.9			
NGC 4902	/	SB(r)b	11.9	39.2			
NGC 6753	/	(R)SA(r)b	11.93	42			

4 - The sub-sample of Milky Way twins (Sbc)

Name	*Sem Red*	*Type NED*	*B(T) mag*	*d Mpc*	*MksT*	*Gr/cl*	
NGC 6744	14A/P	SAB(r)bc	9.24	9.5			
NGC 1566	13B/P	SAB(s)bc	10.21	12.2		Dor gr	WFPC2
NGC 613	14B/P	SB(rs)bc	10.75	25.1			HST; SINFONI H, K
NGC 1792	14B/ok	SA(rs)bc	10.85	13.2			
NGC 134	15A /ok	SAB(s)bc	10.96	18.9			
NGC 157	14B/P	SAB(rs)bc	11.04	19.5			
NGC 4030	14A/ok	SA(s)bc	11.07	24.5			
NGC 5247	15A	SA(s)bc	11.1	22.2			
NGC 1300	13B/T	SB(rs)bc	11.1	18.0	-24.11	Erid cl	ACS/WFPC2; SINFONI H, K
NGC 2442	14A/ok	SB(s)bc pec	11.16	17.1			
NGC 2207	15A	SAB(rs)bc pec	11.35	26.5			WFPC2
NGC 5054	15A??	SA(s)bc	11.51	19.8			
NGC 4939	15A	SA(s)bc	11.56	39			
NGC 7205		SA(s)bc	11.57	19.4			
NGC 1255		SAB(rs)bc	11.6	21.5			
NGC 3887		SB(r)bc	11.6	19.3			

NGC 7314	SAB(rs)bc	11.65	18.5	
NGC 7083	SA(s)bc	11.8	33.3	
NGC 0289	SB(rs)bc		11.81	22.8
NGC 4981	SAB(r)bc	11.83	24.7	
NGC 1515	SAB(s)bc	11.93	16.9	
NGC 1421	SAB(rs)bc?	11.95	26.4	
NGC 5530	SA(rs)bc	11.98	14.	

5 - The sub-sample of late type galaxies (Sc-Sd)

Name	*Sem Red*	*Type Ned*	*B(T) mag*	*d Mpc*	*Gr/cl*				
NGC 253	13B/R	SAB(s)c	8.13	3.1			Phoenix; ACS/WFPC2		
N5236/M83	14A/R	SAB(s)c	8.51	7.0				ACS/WFPC2	
NGC 300	13B/R	SA(s)d	8.7	2.0				ACS/WFPC2	
NGC 1313	12B/R	SB(s)d	9.37	3.9					
NGC 247	15A	SAB(s)d	9.51	3.6		14B Not obs		NIFS(2008)	
NGC 7793	15B	SA(s)d	9.65	4.2		14B Not obs			
NGC 3621	14A/R	SA(s)d	10.03	6.8			GNIRS(Mason); ACS/WFPC2		
NGC 2997	14B/ok	SAB(rs)c	10.32	10.8			ACS/WFPC2		
NGC 1232	15B?	SAB(rs)c	10.5	18.7	Erid cl	14B Not obs		15A	
NGC 5068	15A	SAB(rs)cd	10.53	6.1				15A WFPC2	
NGC 908	14B/ok	SA(s)c	10.87	17.6					
NGC 5643	14A/R	SAB(rs)c	10.89	16.9				WFPC2	
NGC 1187	14B/ok	SB(r)c	10.93	18.8					
NGC 2835	15A	SB(rs)c	10.95	10.8				15A	
NGC 1559	13B/ok	SB(s)cd	10.97	15.7				WFPC2	
NGC 7424	13A/R	SAB(rs)cd	10.99	11.5				WFPC2	
NGC 7090	15B	SBc? e-on	11.1	8.4		14B Not obs		ACS/WFPC2	
NGC 1084	15B	SA(s)c	11.25	21.2					
IC 5332	15B	SA(s)d	11.25	8.4				15A WFPC2	
NGC 1448		SAcd? e-on		11.3	17.4				ACS
NGC 578		SAB(rs)c	11.48	21.8					
NGC 1042		SAB(rs)cd		11.49	9.4				WFPC2
NGC 1637		SAB(rs)c	11.52	10.7					
IC 5201		SB(rs)cd	11.54	14.4					
NGC 4731		SB(s)cd		11.55	19.7				15A
NGC 3511		SA(s)c		11.56	14.3				15A
NGC 1087		SAB(rs)c		11.56	17.5				
NGC 4666		SABc?		11.56	18.2				15A
NGC 7713		SB(r)d?	11.65	10.3					
NGC 1385		SB(s)cd	11.65	14.9	Erid cl				
NGC 3672		SA(s)c		11.66	27.1				
NGC 4487		SAB(rs)cd	11.66	20.0					
NGC 7184		SB(r)c	11.67	33.6					
NGC 4781		SB(rs)d	11.69	16.1					
NGC 1744		SB(s)d	11.7	10.8					
NGC 4775		SA(s)d			11.74	26.6			
NGC 1249		SB(s)cd	11.8	15.8					
NGC 1493		SB(r)cd		11.82	11.3				
NGC 2090		SA(rs)c			11.85	12.8			
NGC 5170		SA(s)c? e-on		11.88	27.3				
NGC 5556		SAB(rs)d		11.88	18.7				
NGC 5334		SB(rs)c?	11.9	32.6					
IC 5273		SB(rs)cd?	11.9	16.6					

NGC 6118	SA(s)cd	11.91	23.4	
NGC 4504	SA(s)cd		11.92	21.8
NGC 5584	SAB(rs)cd	11.95	26.7	
NGC 685	SAB(r)c	11.97	15.2	
NGC 5161	SA(s)c?		11.98	24.3
NGC 3513	SB(rs)c	11.99	13.1	

Appendix D: The original proposal

Abstract

Galactic nuclei are special regions of galaxies, hosting supermassive black holes and stellar populations that record important aspects of the history of the galaxy formation and evolution. In this proposal we aim to perform a survey of nuclei of a complete sample with deep 3D spectroscopy, with a combination of unprecedented spatial resolution and signal-to noise.

We expect to achieve 4 scientific goals: a-***Nuclear emission line properties.*** Detect and study the statistical, geometric and physical properties of Low Luminosity AGN: "dwarf" Seyferts and LINERs as well as starburst nuclei. We propose to carry out the deepest demographic study of supermassive black holes and their local environment yet performed. b-***Circum-nuclear emission line properties.*** Determine the nature and ionization mechanism as well as the kinematics of the line emitting gas in the ~100 pc scale circum-nuclear region. c-***Stellar kinematical properties*** of all nuclei. Mass-to-light ratios will be derived on dynamical basis and compared to those of spectral synthesis and stellar velocity dispersion in order to study the importance of dark matter and the IMF. d-***Stellar populations archeology.*** Study the chemical composition and history of star formation using state-of the-art methods and stellar population models.

The Science Case

Galaxies have been known as entities containing hundreds of billions of stars - islands in the universe - for about 90 years. Their nuclei certainly preserve important information about their origin and evolution. For these reasons it is important to study them, both at the individual level and on a statistical basis. Besides the stellar emission, many galactic nuclei present emission lines that are not originated by stars. They are frequently called Active Galactic Nuclei (AGNs). The luminosity function of AGN is such that they can be studied at large distances. Curiously the most abundant objects are of low luminosity (LLAGN) and not so well studied although abundantly populating the galaxies in the local universe. The LLAGN (as all AGNs) can be classified as type 1 (with broad permitted emission lines) or type 2, without broad emission lines. The presence of a broad component is considered a conclusive proof that the object contains a supermassive black hole.

Most of the massive galaxies host an active nucleus [1], the majority of them presenting low ionization emission lines and hence classified as LINERs (Low Ionization Nuclear Emission Regions [2]). The nuclear emission in LINERs has been proposed to be similar to that of Seyfert galaxies, but in an environment with lower ionization parameter [3, 4]; this idea was confirmed by the discovery of broad Hα emission in a significant fraction of the LINERs as well as the detection of optical non-thermal continuum, high ionization forbidden lines and in X-Rays. Such characteristics are usually associated with a black hole. But it was also found that this low ionization emission can be quite extended in early type galaxies [5], far beyond the ionization produced by a low luminosity central source. The source of this ionization was proposed to be a population of post-AGB stars [6]. In the last two decades significant evidence of nuclear activity has been detected in LINER galaxies [1] but also the evidence of extended post-AGB ionized emission has grown [7-10]. Approximately two thirds of E-Sb galaxies exhibit local weak nuclear activity incompatible with normal stellar processes; in contrast, only about 15% of the Sc-Sm galaxies are known to have AGN activity [1]. Late type galaxies are generally of low mass, gas rich, with strong star formation, bulgeless or associated with pseudo-bulges. These galaxies are frequently characterized as having a central cluster [11, 12]. The nature of these clusters is still poorly understood and they are even considered as failed black holes [13]. It is now well accepted that AGN, Seyfert galaxies as well as most LINERs, are associated with supermassive black holes (BH), with masses ranging from 10^6 -10^10 M☼. It is also well established that there is a strong correlation between BH mass and host galaxy properties [14-16], which has generated great interest in studying the connections between BH growth and galaxy formation/evolution. As a direct manifestation of accretion and growth, BHs have been considered as essential components of structure formation [17-19]. An effective way of studying galaxies and their nuclei is by performing surveys of large samples. With such surveys, new and interesting objects have been found and, if the samples are selected by rigorous criteria, statistical properties can be derived. In this proposal we aim to study a complete sample of galaxies in the southern hemisphere with high (unprecedented) spatial resolution and high signal/noise.

Previous surveys of galaxies and their nuclei in the local universe have been done in the past and that are relevant to the present proposal. PALOMAR: The most popular survey of galactic nuclei[1, 20]. This work has generated a significant number of papers (see [1, 35] for recent reviews) with a large number of citations. This survey is based on single spectra taken with a 2”x4” slit on the Palomar 5 m telescope taken for every galaxy brighter than B=12.5 in the Revised Shapley-Ames Catalog of Bright Galaxies. A total of 486 galaxies satisfy this criterion in the northern hemisphere (delta>0). Important and influential as it was (and still is), the Palomar Survey offers no information on the spatial distribution of the light emitting/absorbing sources. That requires Integral Field Units (IFUs). With the coming of age of IFUs, survey studies are bringing additional capabilities of better studying not only the nucleus itself but also its environment. Some relevant IFU-based surveys are: SAURON – A sample of 327 galaxies were observed with the 4.2 m Herschel telescope [21]. In the low resolution mode the pixel size was 0.94”x0.94” with a spectral resolution of 3.6 A. The spectral coverage did not include the Hα+[N II] as well as the [O I] and [SII] lines, very important to study the AGN. The sample included galaxies with Mb<-18 and $-6^{\circ}<\delta<64^{\circ}$. ATLAS 3D - This survey [22] is an extension of SAURON, but for early type galaxies only. It, again, does not include the spectral coverage of important emission lines. CALIFA - This survey uses the 3.5 m telescope of Calar Alto to observe ~600 galaxies [23]. The main goal is to observe the whole galaxy in the FOV. For this reason the spatial resolution was degraded to ~3” and is not optimized to study the nucleus. Other surveys such as MANGA and SAMI are being planned with IFUs to observe large samples at higher redshifts *a la* Sloan Survey.

The GSGN will obviously benefit from both the scientific insight and the analysis tools developed for these previous and ongoing IFU surveys. Yet, it will explore a spatial scale **not resolved** by these surveys. While CALIFA (as SAURON and ATLAS 3D) reveals the spatial arrangement of phenomena which are all mixed up in Palomar and SDSS data, GSGN will map physics which is blurred in the data cubes of those surveys. For instance, the GSGN FoV spans just ~ a couple of spatial resolution elements of CALIFA! GSGN will thus map physical processes in the nuclear and circum-nuclear scales (100 pc) to a degree of detail (**20** pc resolution) which is completely **out of reach of other surveys**. No other IFU survey is aiming at this sweet spot region of galaxies, where high stellar and gaseous densities, high metallicities, presence of (active or dormant) supermassive black holes and other extreme conditions drive a variety phenomena seen nowhere else in galaxies: scattering cones, obscuring torus, the NLR, BLR, inflows and outflows, nuclear clusters, inner gaseous and stellar disks, etc.

The exquisite spatial resolution of GSGN will allow us to investigate the connection between AGN and its surrounding stellar population to an unprecedented level of spatial detail, shedding new light on long standing puzzles. For instance, while type 2 Seyferts show a clear tendency to host recent star-formation [38-41], it is unclear whether this also happens in type 1

Seyferts. The unadorned unified model implies that type 1s should also exhibit such young stars, but it may also be that, over time, the mechanical and radiative action of star formation and the AGN dissipates the obscuring torus, clearing the view towards the nucleus and making a type 2 evolve to a type 1. Studying this issue requires disentangling the different spectral components, which is best achieved through IFU of the inner ~ 100 pc.

The statistics of LLAGN is limited by the sensitivity of the detection techniques. We believe that, with the techniques developed by our group (30, 32, 36, 37, 50-52; see Figs 1 and 2), we are able to detect AGN at significant lower luminosity limits than the current level of detection such as in the Palomar Survey. We base this belief on two facts: We are concluding a mini-survey of massive galactic nuclei, comprising an unbiased sample of 36 southern galaxies. Our preliminary statistics indicate that we found two times more objects with broad Hα then anticipated from the Palomar survey. This is probably due to the fact that we have much better spatial resolution. A second and perhaps more important argument comes from the Log N x Log S analysis of AGN present in Sc-Sd galaxies. There is a very strong tendency of such objects to appear in the nearest galaxies only. In X-rays a larger proportion than expected has been detected but X-rays are poised by binaries and the statistics are not all that reliable [24]. More reliable is the detection of [Ne V] at 14 and 24 micron (MIR) [25] that suggests that the presence of AGN could be possibly 4 times higher that determined at optical wavelengths.

LINERs also pose interesting questions. If star formation and AGN are indeed interconnected (possibly with a time-delay due to AGN feedback quenching star formation [47], then the fact that LINERs reside among old stars poses a puzzle. Maybe the once young and luminous stars present in an earlier Seyfert phase dim to a level where they can no longer be detected in contrast to the much brighter bulge population, especially when observed through large apertures. Again, the spatial resolution of GSGN, coupled to our sophisticated analysis techniques, will help identifying stellar population variations. Based on SDSS data, it was proposed [9] that LINERs containing true AGN show some residual level of recent star formation in the last Gyr, while those LINERs where stars are all old are not truly AGN, but retired galaxies [7], where the ionizing photon budget is dominated not by an AGN but hot post-AGB stars and white dwarfs. With the much greater sensitivity to AGN signatures of the GSGN will help disentangling true from fake AGN.

Our proposal: The Gemini Survey of Galactic Nuclei (GSGN). We propose a survey of galactic nuclei in the southern hemisphere inspired on the Palomar Survey. This will be, in fact the first such a survey of galaxies in the local universe done in the southern hemisphere. But it is not meant to replicate the Palomar Survey. First it is designed to go much deeper (although for a smaller sample): It will use an 8 m telescope (instead of 5 m) with updated detector technology. More importantly, it will be made with 3D spectroscopy instead of a single slit. It will have a spatial resolution limited by seeing instead of a single spectrum with 4”x2”. In fact this survey will have the highest spatial resolution of any survey of galaxies done or in progress. The scientific goals of our survey are: ***a-Nuclear emission line properties.*** Detect and study the statistical, geometric and physical properties of Low Luminosity AGN (LLAGN): “dwarf” Seyferts and LINERs as well as starburst nuclei. We propose to carry out the deepest demographic study of supermassive black holes and their local environment yet performed. ***b-Circumnuclear emission line properties.*** We expect to determine the nature and ionization mechanism of the line emitting gas in the circum-nuclear region with a ~100 pc scale. We have found that in a few cases one can see the light of the AGN being reflected by the ionization cones [31, 36, 50, 51]. This is an additional demonstration of the existence of a central black hole. It also demonstrates the application of the unified model to LLAGN. These findings were made with the use of PCA tomography [30] and many more such configurations could be found in the survey [31]. Gaseous kinematics may also provide important information about the black hole mass and the geometry of the emitting region [52]. ***c-Stellar kinematical properties***. This will allow to determine the mass of the black hole for the nearest massive galaxies as well as to recover important parameters as the existence of stellar discs and their angular momentum. We will determine the stellar parameters related to kinematics (Gauss-Hermite moments [26]). With those, it is possible to measure the angular momentum related parameter λ_R [28]. This is the parameter that defines, in combination with the eccentricity, slow and fast rotators. We intend to relate λR to other parameters such as galaxy morphology, galaxy stellar luminosity, AGN properties, galaxy environment (groups, clusters etc). For this purpose, we will use the Jeans [29] and the Schwarzschild methods. We will also determine the mass to light (M/L) ratio whenever it is possible and correlate this with other parameters such as velocity dispersion [27] or IMF [28]. ***d-Stellar population archeology.*** Techniques to dissect the fossil record of star formation and chemical histories encoded in galaxy spectra have matured tremendously over the past decade. Both index-based and full spectral fitting methods have been perfected and used to explore the avalanche of data from surveys like the SDSS [32, 41-43], advancing our understanding of the global (spatially integrated) SFH of galaxies of different types. Stellar population models also developed significantly over the last years, making possible to estimate the time scale of the star formation history via the measurement of alpha-enhancements in integrated spectra [48, 49]. These stellar archeology techniques recently started to be applied to IFU-based surveys like ATLAS^{3D} and CALIFA [44, 45], producing SFH maps with ~ kpc scale resolution. Elaborated pipelines have been devoted to explore the highly informative manifold resulting from combination of the spatial information with the age/chemical abundances/extinction record [46].

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Experimental Design

The **SAMPLE**: From a Log N-Log S type of argument one can show that the Revised Shapley-Ames Catalog of Bright Galaxies [33] is nearly complete to B=12.4. At B=12.5 the degree of incompleteness starts to be significant. It is also clear that the sample is complete to |b|>15˚. For the sample to be feasible in the LLP program we have chosen all galaxies with B<12.0, δ<0˚ and |b|>15˚. This sample has a total of 181 galaxies. From them, 11 are Sm/Im in which one cannot identify a nucleus in the 2MASS images. The total number of our sample is therefore 170 galaxies. A sub-sample of 36 massive galaxies (σ>200 km/s) have already been allocated time in 2013. In addition, 7 galaxies have already been observed in other programs (NGC 253-300-908-1068-1313-1566-7424). Why a sample limited to B=12.0 and not to any other limit? In surveys like this, the larger the sample, more accurate the conclusions. With the limit of B=12.0 our uncertainties will be of ~7.4%. With a limit of B=12.5 the accuracy would increase to 5.2% but it would cost twice as much telescope time, and would not be feasible within the limits of our LLP program. **The STRATEGY:** The remaining 127 galaxies demand about 135 hours of observations, considering that on average each galaxy needs 1.06 hs of telescope in order to achieve S/N ~10 per fiber. We propose to complete the GSGN survey in 8 semesters, requiring about 17 hours per semester (see Table 1 and technical description). We will use a strategy of prioritizing 5 sub-samples of galaxies: a- The massive galaxy (MG), with σ>200 km/s. This comprises a total of 36 galaxies. b- Early type (ETG) – galaxies of morphologies E+S0. c- All LTG (late type galaxies) with B<11.5. We will call this the Sc sub-sample. d -All LTG to B=12.0. e - All other galaxies.

The GSGN is LEGACY project. As in the standard Gemini procedure, all data will be available to international access as soon as the proprietary period is over. More than that, we will offer all our reduced and processed data cubes to the Brazilian community, by request, 6 months after each of the subsample processing has been completed. For each galaxy the fully reduced and processed data cube will be available. This means that we will have 170 data cubes with 4800 spectra each. The total of 700 thousand fully processed spectra will be made available to the Brazilian community. The GSGN team comprises experts in all areas related to this field, from stellar libraries and evolutionary tracks (major ingredients in the analysis of stellar populations) to spectral fitting, emission lines, sophisticated data reduction and analysis tools, as well as the organization and distribution of data and value added products in public databases. After the reduction, a data treatment will be applied with the following routines, all developed and validated by our group [36]: DAR correction; Butterworth filtering of spatial and spectral high frequency noises; removal of instrumental fingerprints; R-L deconvolution. The data will be analyzed with the following techniques: PCA Tomography [30, 31]; determination of the stellar Gauss-Hermite moments with the pPXF procedure [26]; stellar spectral synthesis [32] and archeology; analysis of the residual emission lines, after the stellar continuum subtraction with traditional diagnostic diagrams [19]. In addition we will also test a new method to detect AGN, associated with high and low density clouds [37].

The proponent´s responsibilities: **Joao Steiner** (coordination); **Roberto Cid Fernandes** (Methods of spectral synthesis; stellar archeology); **Paula Coelho** (study and definition of stellar template basis; stellar archeology); **Natalia Vale Asari** (analysis of objects with faint emission lines/retired galaxies; dust diagnostics; emission line modeling); **Roberto B. Menezes, Tiago V. Ricci and Daniel May** (Interaction with the Gemini Observatory; data reduction; data processing: DAR correction, fingerprint removal, Butterworth filtering, deconvolution, PCA Tomography; starlight spectral synthesis; emission line analysis); analysis and modeling of stellar kinematics; **André Luiz de Amorim** (Database; analysis tools).

Please note that for 2014A we are submitting two related projects, with a total of 17 hs (Table 1). The accompanying project of Sc galaxies (Menezes et al) is being re-submitted as it has already been initiated. Even if our LLP project is not approved, it makes sense to be continued.

Technical justification

All of the observations will be performed with the GMOS-IFU in the single slit mode. The early-type galaxies will be observed using the B600 grating, in a central wavelength of 5620 Å. Such configuration provides a spectral coverage from 4250 Å to 7000 Å and a spectral resolution of 3.3 Å at 5620 Å. We require this spectral coverage in order to detect emission lines like Hβ, [O III] λ4959; 5007, [O I] λ6300, [N II] λ6548; 6584, Hα and [S II] λ6716; 6731, which are considerably important for our purposes. We propose to obtain three observations, of 10 min integration each, of each one of the early-type galaxies. The late-type galaxies will be observed using the R831 grating, in a central wavelength of 5850 Å. Such configuration provides a spectral coverage from 4800 Å to 6890 Å and a spectral resolution of about 1.3 Å at 5850 Å. We require a higher spectral resolution in the observations of the late-type galaxies because many of them show significantly low values of the stellar velocity dispersions; therefore, a high spectral resolution is required in order to measure this kinematical parameter. We propose to obtain three observations, of 15 min integration each, of each one of the late-type galaxies.

Using the GMOS ITC for our faintest early-type galaxy (NGC 1700), whose source is an elliptical galaxy with 16.71 Bmag/arcsec^2 on the central region. The medium signal to noise is about 26 in this case. On the other hand, using the GMOS Integration Time Calculator for our faintest late type galaxy (NGC 5584), we concluded that it is possible to obtain a median S/N of about 10, except at wavelengths corresponding to the main emission lines, where the S/N is considerably higher. The surface brightness (an input parameter for the ITC) was calculated by taking the flux of the central region of NGC 1042 corresponding to the field of view of the IFU (17.5 square arcsec) as being equal to, approximately, 9% of the total flux of the galaxy. This flux fraction was estimated using an HST image of this galaxy. Our previous experiences revealed that our methods of analysis require a minimum S/N of about 10 in order to provide reliable information.

We propose to obtain an arc lamp observation for each target. Considering, for the early-type galaxies, a 18 min telescope setup time per target plus a 1.5 min exposure corresponding to the observation of the arc lamp image plus 76 s per exposure to cover the readout time, we estimate that, for each early-type galaxy, it is necessary an integration time of 18 min + 3*(10) min + 3*76 s + 1.5 min + 76 s = 54.57 min = 0.91 hr. On the other hand, considering, for the late-type galaxies, a 18 min telescope setup time per target plus a 5 min exposure corresponding to the observation of the arc lamp image plus 76 s per exposure to cover the readout time, we estimate that, for each late-type galaxy, it is necessary an integration time of 18 min + 3*(15) min + 3*76 s + 5 min + 76 s = 73.07 min = 1.22 hr.

Since our sample comprises 62 early-type galaxies and 58 late-type galaxies, we require a total of 62*0.91 hr + 58*1.22 hr = 127.18 hr to complete the program. We require the following observing conditions: Sky Background = 80%, Cloud Cover = 70%, Image Quality = 70% and Water Vapor = Any. Under these conditions, which correspond to 39.2% of all observing nights, no target in the 2014 A semester has a probability of finding guiding stars lower than 33%. Since we do not require specific position angles for the observations, the probabilities of finding guiding stars lower than 100% obtained with the Phase I Tool will probably not represent problems for the observations.

Table 1: The requested time, per semester

	MG	Sc (B<11.5)	GSGN
2013A	*14.1hs*	*2.5 hr*	
2013B	*12.3hs*	*3.9 hs*	
2014A		10.4 hs	6.6 hs
2014B			17 hs
2015A-2017B			17 hs/semester

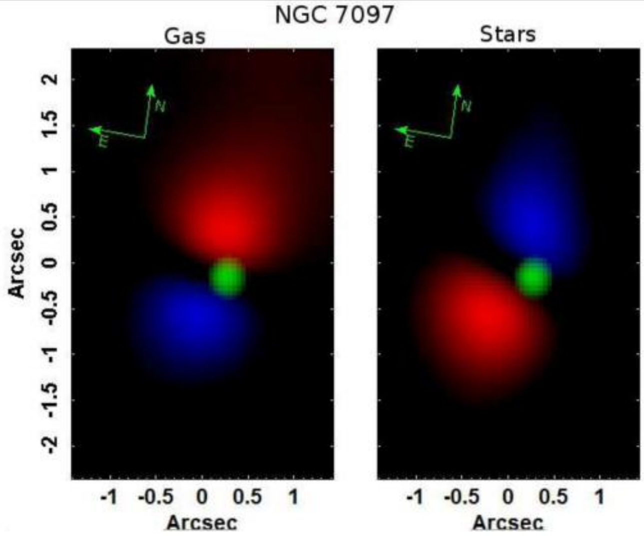

Figure 1 – Tomograms (se [30, 51] for definitions]of NGC 7097 representing the counter rotating gaseous and stellar disks (blue and red) as well as the AGN (green).

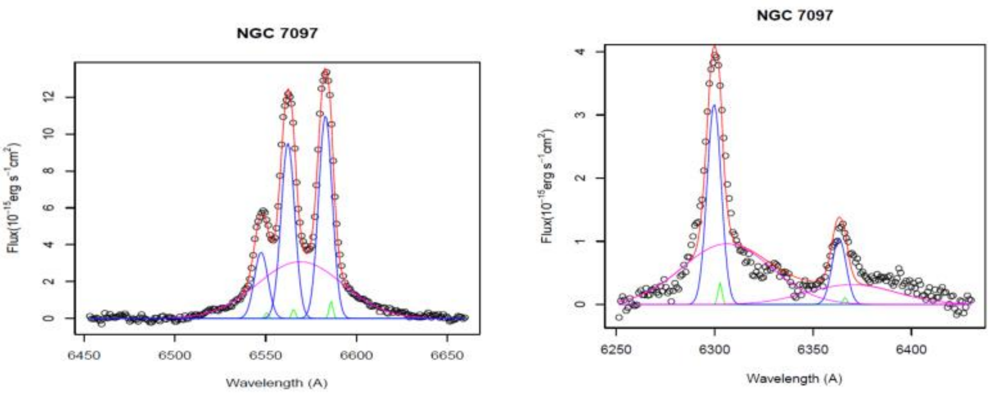

Figure 2. Left: Gaussian decomposition of the Hα */[N II] lines, showing the broad and narrow components. Right: The same for the [O I] lines showing again the broad (surprising!) and narrow components.*