Seminar II: Non-cosmological redshifts

General instructions

This document provides preparation instructions for the second of the two seminars forming part of the examination for the 2004 version of the course *Galaxies, 5 points*. The topic of this seminar is *Non-cosmological redshifts*, an extremely controversial subject in extragalactic cosmology.

The point of this exercise is to:

- Practice reading technical research papers (as opposed to popular articles, review papers or textbooks). As a professional astronomer most of the stuff you will read is likely to be of this variety.
- Practice critical reading (for this purpose, speculative and controversial seminar topics have deliberately been chosen).
- Practice creativity. The answers you need may not be in the suggested literature – or in *any* publication for that matter. You may simply have to come up with a solution on your own.
- Practice information retrieval (learning not to waste time reading off-topic papers is an invaluable skill).
- Practice presenting material in front of an audience.

In preparing for the seminar, you should try to:

- Develop some insight into the field of non-cosmological redshifts by studying the relevant literature. In doing so, the seminar questions listed may serve as guidance as to what you should focus on.
- Prepare to explain and discuss various concepts and recent results relevant to this field in front of the class. The use of the blackboard or overhead projector is highly encouraged.
- Analyze the enclosed non-cosmological redshift data set and prepare to present your finding to the class (using e.g. blackboard or transparencies).

You are perfectly welcome to collaborate with your classmates when preparing for the seminar, but once there – everyone is on their own. This means that you are not supposed to rely on the calculation, notes, viewgraphs etc. of others.

Suggested reading

A couple of good places to start are:

- Burbidge, G. 2001, PASP 113, 899
- Burbidge, G. 1996, A&A 309, 9
- Arp, H. & Russell, D. 2001, ApJ 549, 802.

Please note that these papers represent the *minimum* reading required for the seminar. It is highly recommended that you study other articles as well. When looking for relevant papers, you may find the following keywords useful:

- Non-cosmological/anomalous redshift
- Variable mass hypothesis

- Quasar-galaxy associations
- Quasar ejection
- Redshift periodicities

The recommended article databases are:

- http://adsabs.harvard.edu/abstract_service.html (published papers only; requires Observatory computer account)
- http://arxiv.org (preprints, some of which are too strange to ever get published)

Seminar questions

Here are a few examples (i.e. not a complete list) of questions that may come up during the seminar:

- Why are most astronomers sceptical about non-cosmological redshifts?
- What is the observational evidence is favour of non-cosmological redshifts? How strong is it?
- For what kinds of objects have claims of non-cosmological redshift been made?
- Are there any mundane astrophysical explanations for these redshift anomalies?
- If redshift is not caused by the expansion of the universe, what could be the physical reason for it?
- Do non-cosmological redshifts, if real, contradict standard cosmology?
- Is there any way to test the different claims for non-cosmological redshifts? (Be inventive!)

A non-cosmological redshift case study

One of the proponents most furiously defending the notion of non-cosmological redshifs publishes a large catalogue of quasar-galaxy associations which are said to constitute the strongest cases for the reality of redshift anomalies. In this catalogue, you come across the system ESO 666-01, which does not appear to have been discussed in the previous literature. Eager to make a name for yourself, you set out to unravel the mysteries of this little-known galaxy.

Fig. 1 displays the vicinity of the Seyfert galaxy ESO 666-01. The available data (including redshifts, apparent B-magnitudes, $U - B$ colour, object classification and angular coordinates centered on ESO 666-01) for some of the surrounding objects is given in Table. 1. Please note that the data is incomplete, and that the classification is very crude and has been generated by some automated algorithm.

The following question may provide some guidance when investigating the ESO 666-01 system:

- Why is the field around ESO 666-01 referred to as a strong case in favour of non-cosmological redshifts?
- Is there evidence suggesting that some of the objects surrounding ESO 666-01 may have been ejected from it?
- Is it possible to come up with some scenario (no matter how outrageous) which explains the properties of some of the surrounding objects? Is there any way to test this scenario through future observations?

Erik Zackrisson, March 2004

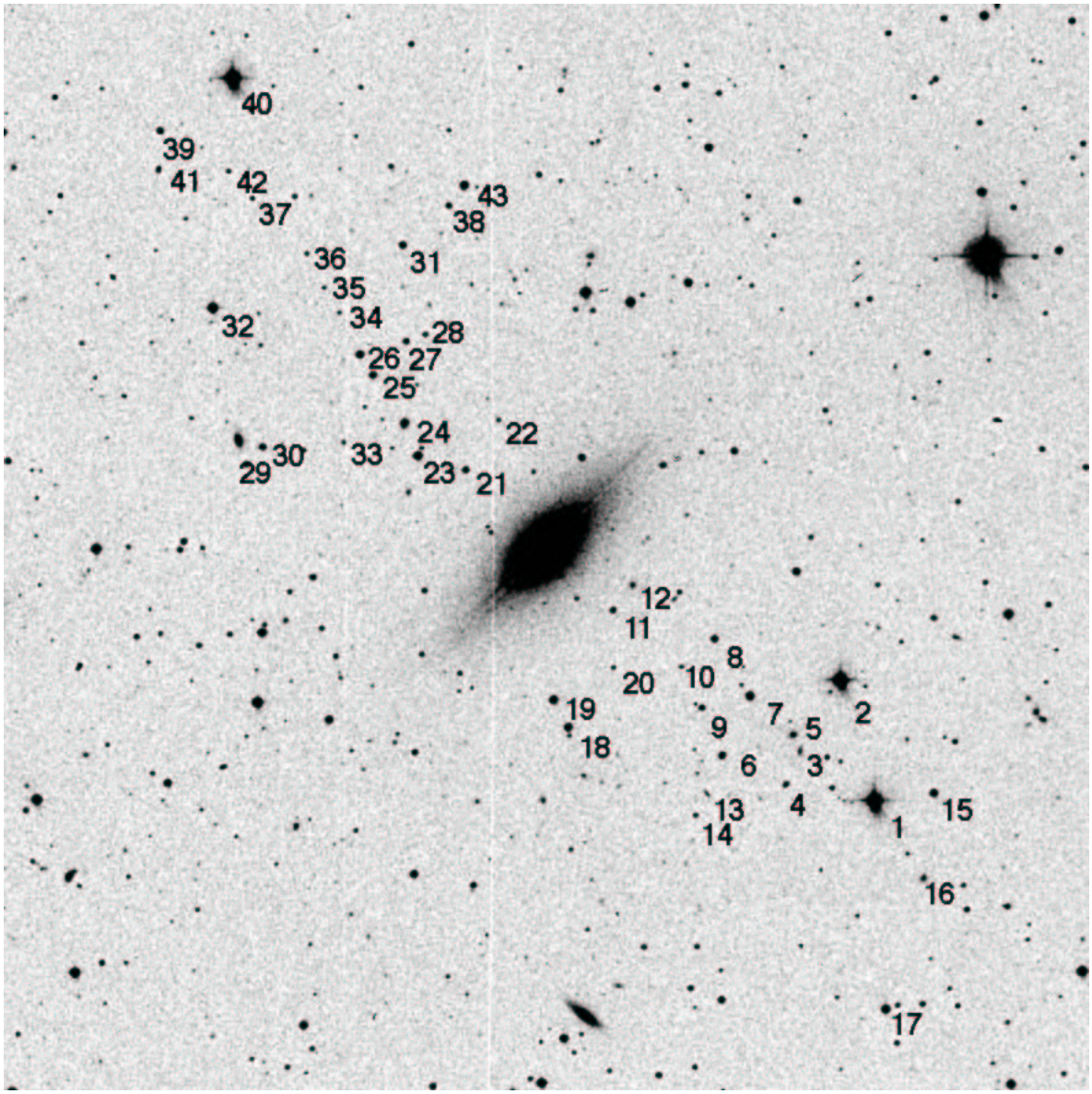

Figure 1: 25'× 25' optical image of the edge-on active galaxy NGC 666-01 (centre). Numbers refers to objects for which data is given in Table 1. The label is typically located to the lower right of each object. The white vertical lines (most notably right across the disk of NGC 666-01) in this image are caused by bad columns on the telescope CCD.

Table 1: Data for objects in the field around NGC 666-01. Numbers refer to the labels of Fig. 1. The origin of the coordinate system (units: arc minutes) is at the centre of this galaxy. Classification abbreviations: QSO = Quasi-stellar Object / Quasar, P = Point source, S = Star, G = Galaxy, ? = Uncertain. A missing entry in the redshift column may either indicate zero redshift or no available measurement. Please note that the numerical part of this table is also available as an ascii data file, which may be downloaded from the laboration home page. In that file, missing redshifts have been entered as 0.000.

Object	x	y	Classification	z	$U-B$	B
NGC 666-01	0.0	0.0	G	0.0074	0.55	11.41
1	7.5	-5.8	QSO	0.901	-0.45	18.41
2	6.7	-3.1	S	-	0.53	18.67
3	5.7	-4.7	G	0.867	0.31	21.34
4	5.4	-5.5	G	0.520	1.52	20.12
5	5.6	-4.3	G	0.411	1.21	19.83
6	3.9	-4.8	QSO	1.282	-0.61	19.64
7	4.6	-3.5	QSO	1.249	-0.34	19.77
8	3.8	-2.2	S	-	1.82	19.80
9	3.5	-3.6	?	-	1.91	20.16
10	3.0	-2.8	?	-	1.88	21.04
11	1.4	-1.5	QSO	1.267	-0.43	20.02
12	1.9	-0.9	S	-	0.65	19.87
13	3.7	-5.6	G	0.655	1.19	20.95
14	3.5	-6.1	?	-	1.68	21.13
15	8.9	-5.7	S	-	-0.14	19.77
16	8.6	-7.6	?	0.361	0.52	20.24
17	7.6	-10.6	P	-	0.87	19.43
18	0.4	-4.3	?	-	0.74	18.34
19	0.1	-3.5	P	-	1.43	19.49
20	1.4	-2.8	S	-	0.96	20.87
21	-1.9	1.8	QSO	1.230	-0.78	20.13
22	-1.2	3.0	S	-	0.33	20.86
23	-3.0	2.1	P	-	0.99	19.63
24	-3.3	2.8	?	0.320	1.10	19.39
25	-4.0	4.0	QSO	1.274	-0.53	19.43
26	-4.4	4.5	QSO	1.242	-0.41	19.66
27	-3.2	4.7	S	-	0.44	20.48
28	-2.8	4.9	S	-	-0.10	20.61
29	-7.2	2.5	G	-	1.45	18.82
30	-6.1	2.4	?	-	-0.16	19.63
31	-3.3	7.0	S	-	0.34	19.34
32	-7.7	5.5	QSO	0.949	-0.39	18.69
33	-4.7	2.4	P	-	1.97	21.22
34	-4.8	5.4	S	-	0.86	20.87
35	-5.2	6.0	S	-	1.43	21.04
36	-5.5	6.8	S	-	1.78	20.78
37	-6.8	8.0	S	-	-0.01	20.54
38	-2.2	7.9	P	-	1.23	19.98
39	-8.9	9.6	?	1.210	0.55	20.17
40	-7.1	10.6	P	0.621	-0.46	17.94
41	-8.9	8.7	G?	0.697	0.47	20.11
42	-7.3	8.7	P	-	0.21	20.48
43	-1.8	8.4	P	-	1.09	19.75