UNIVERSITY COLLEGE LONDON

University Of London Observatory PHAS1510 – Certificate in Astronomy, 1213.01

PHAS1510-04: Palomar Sky Survey Prints: Virgo and Hercules Clusters

Name:_____

An experienced student should aim to complete this practical in 2 (and not more than 3) sessions.

1 Items Required

You will need:

- Palomar Sky Survey prints O–1563 and O–83;
- masking tape (*do not use any other kinds of tape*);
- measuring graticule magnifier;
- light-box (optional);
- transparent grid overlay with 5mm squares (optional).

2 Introduction

The prints provided for this exercise were obtained using the 48-inch Schmidt telescope on Mount Palomar. This telescope was designed with a large field of view so that the whole sky visible from Palomar could be surveyed in a reasonable time (∼10 years), including almost the faintest objects that could be photographed. The photographs were made on glass plates, from which these contact prints were made.

Please be extremely careful when handling these prints; hold them by the edges only and do not touch the photographic surface. When working with them, keep them in their transparent jackets and *do not write on paper that lies over the prints.*

You may (or may not) find it easier to view the prints using a light-box; and a transparent grid can be placed on top of the print to give a suitable coördinate system for your findings, although simple measurements with a ruler may be entirely satisfactory. Masking tape can be used to hold the grid fixed with respect to the print.

In the upper left hand corner of each print is a small box containing important information; for example,

O–1563 Mar 10/11 1956
$12^h28^m48^s$ $+11^\circ28'42''$

The letter O denotes the sensitivity of the plate (O indicating that it is blue sensitive*); the number following is a serial plate number. Then follows the date of observations, and, finally, the right ascension and declination of the centre of the plate.

*This non-intuitive nomenclature follows from designations given by Kodak to their emulsions. For each 'O' plate, there is a matching, red-sensitive 'E' plate.

Each print covers ∼6° by 6° on the sky. The plate scale of 1.12 arcminutes per millimetre corresponds to roughly half a degree (the diameter of the Moon) per inch. Note that these prints are negatives. Stars and galaxies show up black, and (for stars) the brighter the object, the larger is the image on the print.

The Observatory has a complete collection of Palomar prints which students are welcome to examine under appropriate supervision; these have been used for numerous research projects. The Observatory also has the ESO and Anglo–Australian Schmidt surveys of the Southern sky on film copies. Several examples from this set are available to students. Although the prints have been superceded by digitized versions for many purposes, they still retain greater information content than digital copies, and have to be refered to in critical applications.

Work through the following sections, examining the prints and answering the questions in the spaces provided. Write complete answers to the questions, including your reasoning and, if relevant, sketches or additional notes from reference material. When sketching, always include a *scale,* and label your diagram clearly.

3 Galaxy Types and Galaxy Clusters

A galaxy is a huge assembly of gravitationally-bound stars, gas and dust. Most galaxies (maybe all) are members of various types of clusters. The Milky Way (our galaxy) is a member of a rather small cluster called the Local Group, which in turn is part of a local supercluster that also includes the Virgo cluster.[†]

In this exercise you will need to be able to identify different types of galaxies according to their appearance. The majority of galaxies may be separated into two major categories: *elliptical galaxies* and *spiral galaxies* (see the 'Classification of Galaxies and the Hubble Deep Field' practical for more details).

3.1 Elliptical galaxies

This type of galaxy contains mainly old stars with little dust or gas in an elliptical shape. They show no spiral structure. Their brightness drops steeply from the centre outwards. When identifying them, check for their elliptical shape and the drop in brightness.

3.2 Spiral galaxies

These galaxies have spiral shaped arms, picked out by the blue stars within them; the Milky Way is a spiral galaxy. When these galaxies are viewed edge on they appear as a central nuclear bulge with a distinct disc about the nucleus, with a thin *dust lane* often visible. The brightness of the nucleus falls off steeply, as in elliptical galaxies, whilst the surface brightness of the disc decreases realtively slowly away from the nucleus.

N.B.: Examples of elliptical and spiral galaxies are shown in reference 1. Take some time to become familiar with pictures of these different galaxy types before you answer any of the questions below.

[†]The nearest, brightest clusters are uniquely identfiable by the name of the constellations within which they lie.

4 Print O–1563: The Virgo Cluster

Measurements should be taken with respect to the *outside* of the black border, in millimetres, with the bottom left corner as (0,0). [You should check that there is a moderately bright star at coördinates (x, y) = (33, 126) on O–1563 to be sure you're using the right coördinate system.]

If you want to use an overlay grid, align it so that the origin of the grid is exactly on the bottom left-hand corner of the black border and the axes of the grid are aligned with the border. Secure lightly with masking tape.

This print shows the centre of the Virgo cluster. The bright galaxy above the plate centre is M87. By using the magnifier provided, many of the galaxies within the Virgo cluster can be classified by comparing their appearance with the descriptions of elliptical and spiral galaxies given above. Many stars within the Milky Way also appear on the print.

Q.1 How does one distinguish faint galaxies from stars?

Q.2 (*i*) Find 10 elliptical galaxies on O–1563, and give their coördinates in the table below. Sketch three of them in the space beneath the table.

No.	Coördinates of Elliptical Galaxy
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

(*ii*) Find 10 spiral galaxies on O–1563, and give their coördinates in the table below, stating their orientation (i.e., face-on, edge-on, or in-between). Sketch one of each orientation in the space beneath the table.

No.	Coördinates of Spiral Galaxy	Orientation of Spiral Galaxy
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Q.3 (*i*) There are three reasonably obvious cases where galaxies seem to be associated on O–1563. Give their coördinates and sketch them.

(*ii*) Decide which of the three is most likely to be a pair in collision. *(Hint: In a galactic collision, the nuclei of the galaxies tend to be connected by debris.)*

(*iii*) Briefly explain the circumstances of the other two 'associations'.

5 Print O–83: The Hercules Cluster

Set up Print O–83 using the same guidelines provided for the Virgo cluster print. This print includes the Hercules cluster just above the centre of the plate. The galaxies are harder to classify as they are more distant, hence smaller and harder to recognise; however, the phenomenon of clustering is more evident. (This print actually shows more than one cluster, but we will mainly be dealing with the Hercules cluster.)

Q.4 The top and left of the print correspond to North and East, respectively. Look at fig 26-19 on page 594 of reference 1 (fig. 26-20,p. 603 in the 6th edition; fig. 23-3, p. 450 in the 5th edition; fig. 26-21, p. 487, in the 4th edition; p. 442 in the 3rd edition). By examining the Hercules cluster, give the picture's orientation. *State which edition of* 'Universe' *you examined as the orientation changes depending on the edition.* Tip: the published image occupies only a small area of the Palomar print.

There are two main types of galaxy cluster: regular and irregular. Regular clusters tend to be giant, ∼spherically symmetric systems with a high degree of central condensation. They consist very largely of elliptical galaxies. Irregular clusters are smaller and more diffuse, with no obvious single central condensation. They contain a mixture of all types of galaxies. Small groups of galaxies, such as our own Local Group, may be considered as irregular clusters.

Q.5 Is the Hercules cluster regular or irregular? *(Hint - Note ratio of spiral galaxies to elliptical galaxies.)*

References

1. Freedman, R.A. & Kaufmann, W.J., *Universe,* 7th edition; Chapter 26 (especially §26–6).