Appendix for Worksheet 2:

Profiles of 14 galaxy spectra

The galaxies that you will use to create a Hubble diagram were compiled from sources published by the *UNIVERSITY of WASHINGTON*. Specifically, the information was taken from the following page: http://depts.washington.edu/astroed/HubbleLaw/galaxies.html.

The spectra on this page are particularly good for educational purposes, since they are clearly presented and free from irrelevant details. When you click on the links, the spectra show the wavelength in Ångström along the x-axis, which is a very uncommon unit outside of astronomy. You can use the conversion formula: $1\text{Å} = 1 \cdot 10^{-10}\,\text{m} = 0.1\text{nm}$.

The so-called "Redshift Independent Distances" of the galaxies were taken from the data catalogue of the *Infrared Processing and Analysis Center (IPAC)* (https://ned.ipac.caltech.edu). The great uncertainty in the distance data is reflected in the spread of the values. This is unfortunately unavoidable, as measuring the distance of far-away objects is still a very difficult problem in astronomy.

Galaxy NGC 1357

distance: 27.45 MPc $(\pm 2.35$ MPc$)$
$= 89.5$ million light-years $(\pm 7.7$ million light-years$)$

Image source: Adam Block/Mount Lemmon SkyCenter/University of Arizona; CC-BY-SA 3.0 US
https://de.m.wikipedia.org/wiki/Datei:N1357s.jpg

The redshifted H-alpha line in the spectrum of the galaxy is the highest line in the right-hand diagram at the following link: http://depts.washington.edu/astroed/HubbleLaw/ngc1357_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 1832

distance: 24.36 MPc $(\pm 5.8$ MPc$)$
= 79.4 million light-years $(\pm 18.9$ million light-years$)$

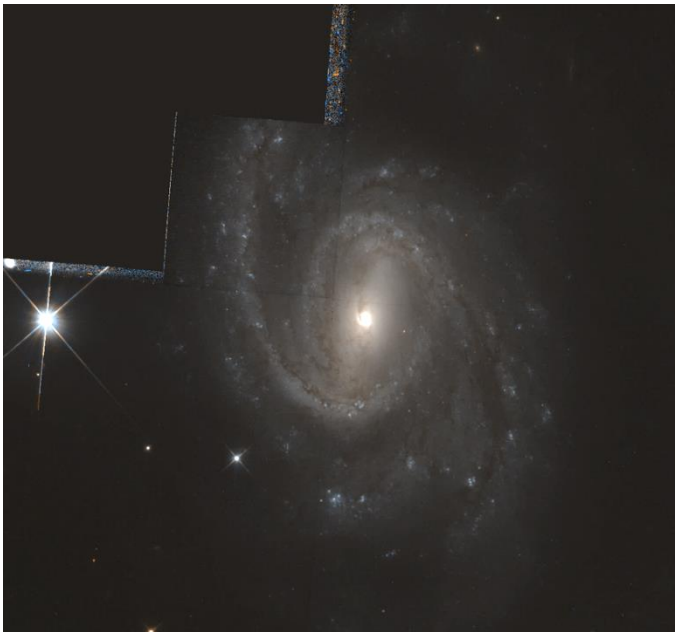

Image source: Fabian RRRR; CC-BY-SA 3.0 nicht-portiert
https://de.wikipedia.org/wiki/Datei:NGC1832_-_hst_10877R814GB555.png

The redshifted H-alpha line in the spectrum of the galaxy is the highest line in the right-hand diagram at the following link: http://depts.washington.edu/astroed/HubbleLaw/ngc1832_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 2775

distance: 15.5 MPc $(\pm 2.1$ MPc$)$
= 50.5 million light-years $(\pm 6.8$ million light-years$)$

Image source: Sloan Digital Sky Survey www.sdss.org; CC-BY 4.0
https://commons.wikimedia.org/wiki/File:NGC2775_-_SDSS_DR14.jpg

The redshifted H-alpha line in the spectrum of the galaxy is the highest line in the right-hand diagram at the following link: http://depts.washington.edu/astroed/HubbleLaw/ngc2775_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 2903

distance: 8 MPc $(\pm 1.9$ MPc$)$
= 26 million light-years $(\pm 6.2$ million light-years$)$

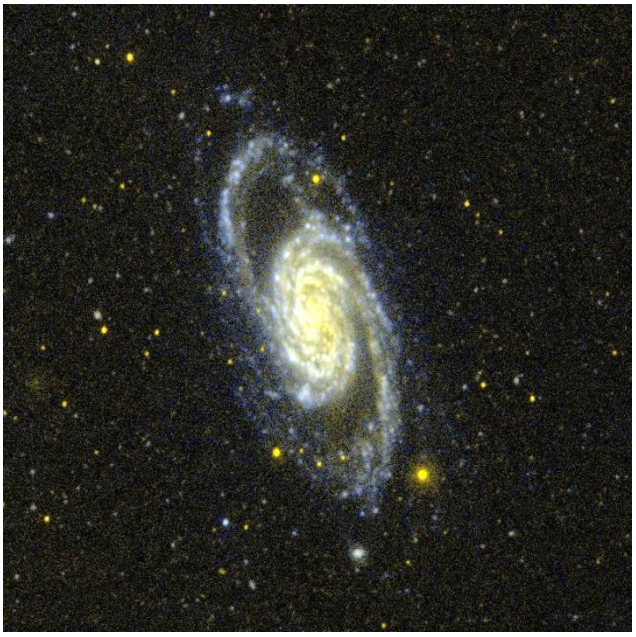

Image source: NASA/GALEX/WikiSky; public domain
https://de.m.wikipedia.org/wiki/Datei:NGC_2903_GALEX.jpg

The redshifted H-alpha line in the spectrum of the galaxy is the highest line in the right-hand diagram at the following link: http://depts.washington.edu/astroed/HubbleLaw/ngc2903_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 3034

distance: 3.9 MPc $(\pm 0.7$ MPc$)$
= 12.7 million light-years $(\pm 2.2$ million light-years$)$

Image source: NASA, ESA, and the Hubble Heritage Team (STScI/AURA); public domain
https://commons.wikimedia.org/wiki/File:M82_HST_ACS_2006-14-a-large_web.jpg

The redshifted H-alpha line in the spectrum of the galaxy is the highest line in the right-hand diagram at the following link: http://depts.washington.edu/astroed/HubbleLaw/ngc3034_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 3147

distance: 39.61 MPc (± 8.95 MPc)
= 129 million light-years (± 29 million light-years)

Image source: Judy Schmidt; CC-BY 2.0
https://commons.wikimedia.org/wiki/File:NGC_3147_-_HST.png

The redshifted H-alpha line in the spectrum of the galaxy is the highest line in the right-hand diagram at the following link: http://depts.washington.edu/astroed/HubbleLaw/ngc3147_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 3227

distance: 18.75 MPc $(\pm 6.3$ MPc$)$
= 61.1 million light-years $(\pm 20.5$ million light-years$)$

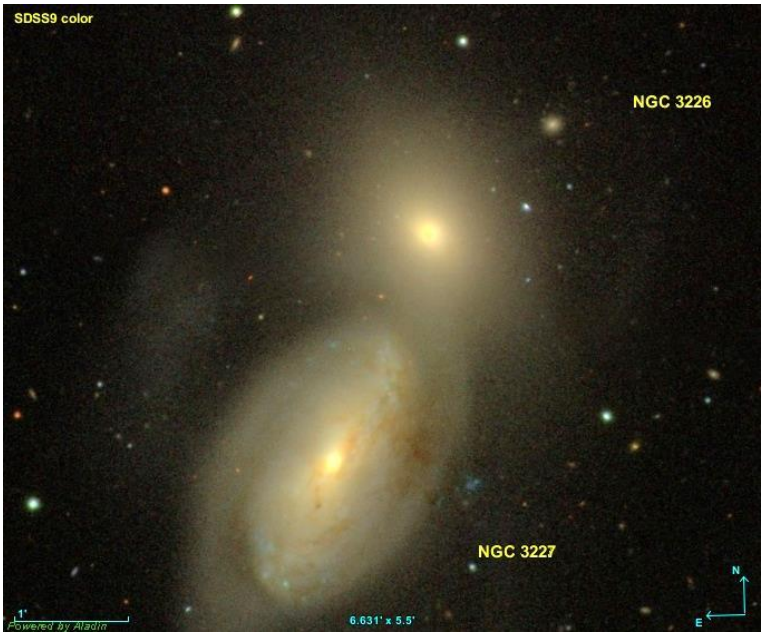

Image source: Donald Pelletier; CC-BY-SA 4.0
https://commons.wikimedia.org/wiki/File:NGC_3226_27_SDSS.jpg

The redshifted H-alpha line in the spectrum of the galaxy is the **second-highest** line in the right-hand diagram at the following link:
http://depts.washington.edu/astroed/HubbleLaw/ngc3227_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 3368

distance: 10.85 MPc $(\pm 1.5$ MPc$)$
= 35.4 million light-years $(\pm 4.9$ million light-years$)$

Image source: ESO/Oleg Maliy; CC-BY 3.0
https://fr.wikipedia.org/wiki/Fichier:NGC_3368_ESO.jpg

The redshifted H-alpha line in the spectrum of the galaxy is the **second-highest** line in the right-hand diagram at the following link:
http://depts.washington.edu/astroed/HubbleLaw/ngc3368_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 3623

distance: 12.23 MPc $(\pm 2.4\text{MPc})$
= 39.8 million light-years $(\pm 7.8$ million light-years$)$

Image source: Adam Block/Mount Lemmon SkyCenter/University of Arizona; CC-BY-SA 4.0 https://commons.wikimedia.org/wiki/File:M65_Galaxy_from_the_Mount_Lemmon_SkyCenter_Schulman_Telescope_courtesy_Adam_Block.jpg

The redshifted H-alpha line in the spectrum of the galaxy can be seen in the right-hand diagram at the following link. It is the line **to the left of the highest line**: http://depts.washington.edu/astroed/HubbleLaw/ngc3623_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 3627

distance: 9.6 MPc $(\pm 1.9\text{MPc})$
= 31.3 million light-years $(\pm 6.2$ million light-years$)$

Image source: NASA/JPL-Caltech/R. Kennicutt (University of Arizona) and the SINGS Team; public domain
https://commons.wikimedia.org/wiki/File:NGC_3627_(M66).jpg

The redshifted H-alpha line in the spectrum of the galaxy is the highest line in the right-hand diagram at the following link: http://depts.washington.edu/astroed/HubbleLaw/ngc3627_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 5248

distance: 13.33 MPc (± 4.1 MPc)
= 43.5 million light-years (± 13.3 million light-years)

Image source: Adam Block/Mount Lemmon SkyCenter/University of Arizona; CC-BY-SA 3.0 US
https://de.m.wikipedia.org/wiki/Datei:N5248s.jpg

The redshifted H-alpha line in the spectrum of the galaxy is the highest line in the right-hand diagram at the following link: http://depts.washington.edu/astroed/HubbleLaw/ngc5248_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 6181

distance: 31.36 MPc $(\pm 5.3$ MPc$)$
= 102 million light-years $(\pm 17.3$ million light-years$)$

Image source: Sloan Digital Sky Survey www.sdss.org; CC-BY 4.0
https://de.m.wikipedia.org/wiki/Datei:NGC6181_-_SDSS_DR14.jpg

The redshifted H-alpha line in the spectrum of the galaxy is the highest line in the right-hand diagram at the following link: http://depts.washington.edu/astroed/HubbleLaw/ngc6181_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 6217

distance: 20.64 MPc (± 7.3 MPc)
= 67 million light-years (± 23.8 million light-years)

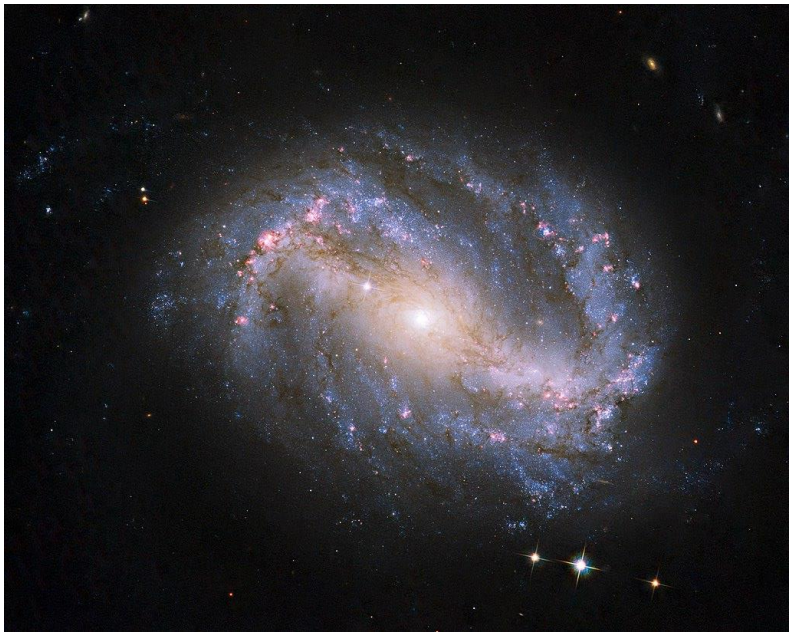

Image source: NASA; public domain
https://de.m.wikipedia.org/wiki/Datei:NGC_6217_hs-2009-25-bc-full_jpg.jpg

The redshifted H-alpha line in the spectrum of the galaxy is the highest line in the right-hand diagram at the following link: http://depts.washington.edu/astroed/HubbleLaw/ngc6217_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

Galaxy NGC 6643

distance: 19.1 MPc $(\pm 3.3$ MPc$)$
= 62.3 million light-years $(\pm 10.8$ million light-years$)$

A representation of this galaxy can be seen here as an example: http://www.deepsky-drawings.com/ngc-6643/dsdlang/fr.

The redshifted H-alpha line in the spectrum of the galaxy is the highest line in the right-hand diagram at the following link: http://depts.washington.edu/astroed/HubbleLaw/ngc6643_main.html.

Note:
When you click on the diagram, the cursor position indicates the wavelength at this point. The value is shown below the diagram. If you click on the tip of the H-alpha line, its wavelength is displayed in Ångström. (If you move the decimal point one place to the left, you get the wavelength in nanometres.)

