Astronomers' Observing Guides

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Brian Cudnik

Faint Objects and How to Observe Them

with 69 Illustrations

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I would like to dedicate this to my astronomy friends who have passed on from this life: Don "Captain Comet" Pearce, Rick Hillier, George Stradley, Richard Bunkley and others. May your legacies shine on like stars in the universe.

About the Author

Brian Cudnik has been an amateur astronomer for over 30 years and manages the Physics laboratories at Prairie View A & M University (a part of the A & M University of Texas). He has been the coordinator of the Lunar Meteoritic Impact Search section of the Association of Lunar and Planetary Observers (ALPO) since January 2000. Cudnik began at ALPO 2 months after it made the first confirmed visual observation of a meteoroid impact on the Moon during the Leonid storm of November 1999. Cudnik has an M.Sc. and has published papers and posters on various astronomical subjects, both peer-reviewed and amateur. He has served as a board member of the Houston Astronomical Society, is presently an Associate member of the American Astronomical Society, a member of the American Meteorological Society, a member of the American Association of Physics Teachers, and a regular contributor of observations to the American Association of Variable Star Observers and the International Occultation Timing Association. He teaches astronomy at the University of St. Thomas two evenings per week each semester.

Preface

Pushing the Envelope in Visual Astronomical Observations

Astronomy encompasses an unimaginably vast and complex universe of objects, from the planets, moons, comets, and asteroids of the local Solar System to the most distant galaxies— and everything in between. Most of what we can see easily or are prone to look at through the eyepiece in the nighttime sky are the nearest and/or the brightest representations of the various astronomical objects. Most amateur astronomers who actively observe have seen the likes of M42, the Great Orion Nebula, or M57, and the Ring Nebula. But how many people have seen PK 013.3 + 32.7? PK 013.3 + 32.7 is also known as Shane 1 and I had not even heard of this object until the summer of 2010, when it was mentioned in the June 2010 issue of *Sky & Telescope* (p. 65 of that issue). Bright, nearby objects are always fun or rewarding to look at, but one can truly expand one's cosmic horizons by hunting down obscure deep sky objects and seeing things that few others have seen.

I have included my own drawings of the Great Orion Nebula, along with the planetary nebulae NGC 6772 and NGC 6872 (which people may or may not have seen, but both appear as very different shapes through the eyepiece) below in Fig. i.1

This book, *Faint Objects and How to Observe Them*, primarily deals with techniques in visual astronomy to enable one to observe these "elusive faint fuzzies." The visual side of astronomy is an art form as well as a science in that a full appreciation of the subtle beauty of astronomical objects takes time to develop. For amateur astronomers who have not done deep astronomy very long, I recommend starting with the brightest, most spectacular objects (and revisit them regularly) like the Moon, Saturn, Jupiter, the Orion Nebula, the Andromeda Galaxy and many others, and continue your pursuits with the brighter deep sky objects. The vast majority of deep sky objects (at least the ones that we can see from Earth) are quite faint, which is the primary focus of this book.

The target audience is the intermediate to advanced visual observer. If you are a beginner who wants to "go deep," you can also benefit from this book; however, it is recommended that you master the ability to locate the brighter Messier and NGC objects before attempting the fainter objects in this book. We will skip over the most basic elements of observing techniques (although there are some refresher tidbits on the basics from time to time) and focus mainly on the skills needed to locate, observe, and appreciate faint objects. Figure i.2 show just how deep the

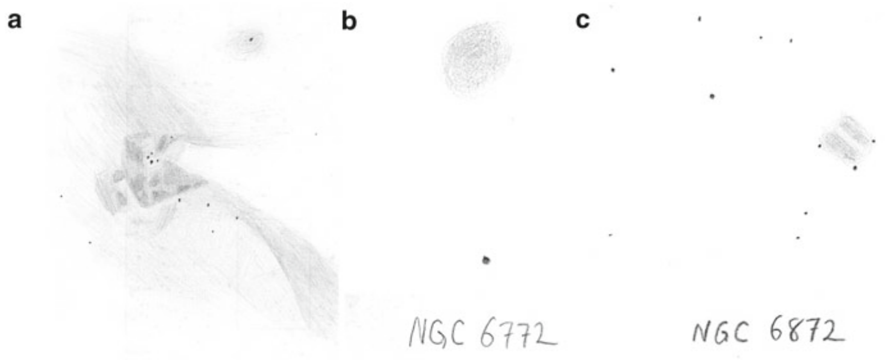

Fig. i.1 Author's drawings of (**a**) M42, (**b**) NGC 6772, and (**c**) NGC 6872. M42 was observed with an 8-in. f/10 Cassegrain at 83× and 226× and under light pollution; NGC 6872 was observed under dark skies, with an OIII filter and a 14-in. f/11 Cassegrain (referred to as the "C14" here and elsewhere in this book) at 244.5×; and NGC 6772 was sighted with the C14, no filter, at 98×

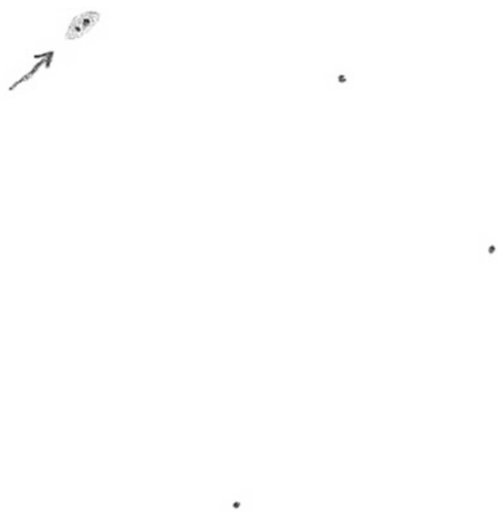

Fig. i.2 Author's drawing of the Ursa Major double quasar, visual observation from the 2003 Texas Star Party, with Larry Mitchell's 36-in. telescope at 300×

author has observed; it is a drawing of the Ursa Major Double Quasar observed during the 2003 Texas Star Party through the eyepiece of a 36-in. (91-cm) reflecting telescope. This object lies some 7 billion light years from Earth.

The term "faint objects" can include a wide variety of objects, from atmospheric phenomena such as sprites (bursts of light above thunderstorms) and other atmospheric transients to Solar. System objects such as faint asteroids, comets and distant dwarf planets, and to objects outside the Solar System such as nebulae, clusters, individual galaxies and galaxy clusters. This book will concentrate on deep sky objects and leave the Solar System objects, however faint, to other books that are dedicated to a particular type of object (for example, faint comets described in the book *Comets and How to Observe Them*, another book in the Springer "Astronomers' Observing Guides" series).

The following historical passage sheds a little light on the discovery of the nature of faint objects as well as the uncovering of even more faint objects. In fact, it was not until the third decade of the twentieth century that we truly became aware of the fact that the Milky Way Galaxy is not the entire universe but rather one of many galaxies in a universe far larger and more complex than we ever imagined up to that point. With larger and larger telescopes being built and the quality of the optics improving in the first decades of the twentieth century, our view of the cosmos became more and more clear. Examples of these large telescopes include the 100-in. (2.54-m) telescope at Mt. Wilson, which became operational in 1917 (Fig. i.3a), and the 200-in. (5.08-m) Palomar Hale 'scope that received its first light in 1949 (Fig. i.3b) and remained the largest telescope in the world until 1976. At this time the BTA-6 telescope in Russia became operational as the world's largest, and would remain so until the Keck I telescope (Fig. i.3c), at 387 in. (10 m) became the world's largest telescope in operation in 1993. With these larger telescopes and the wider and more effective use of photography, nearby galaxies, for the first time, became resolved into individual stars.

Galaxies, the so-called "spiral nebulae" of the eighteenth and nineteenth centuries, were noted during the surveys that will be described in more detail in Chap. 1. They were thought to be planetary systems in the making, all within our own galaxy. In 1920, two astronomers, Harlow Shapley and Heber D. Curtis, began what would later be called the Shapley-Curtis debate. Curtis argued that the universe was much larger than had been accepted up to this point, being composed of many galaxies (the "spiral nebulae") like the Milky Way. But Shapley argued that these objects were actually nearby gas clouds, and that the universe was made of only one great big galaxy. The Sun, in Curtis's cosmogony, was near the center of our relatively small galaxy; Shapley contended that the Sun was far from the center of the galaxy.

The realization by the mid 1920s that the Andromeda Galaxy is actually made up of numerous stars, along with other discoveries in the 1930s, partially resolved this debate. Edwin Hubble was instrumental in the first discovery, as special types of variable stars called Cepheids were discovered in Andromeda. This, combined with the work of Henrietta Leavitt (an American astronomer who discovered the period-luminosity relationship of these objects), made it possible to find the distance to Cepheid variables in Andromeda, and by extension, Andromeda itself. Hubble's work also revealed that galaxies were receding from us at speeds proportional to their distances, and the expansion of the universe was discovered (this discovery led to the Big Bang theory of the origin of the universe which, as of this writing, remains the leading explanation of the origins of the Cosmos; our changing view of the universe over the last millennium is illustrated in Fig. i.4).

More on the Shapley-Curtis debate: it seems that both astronomers were correct to an extent. Shapley was more correct about the size of the Milky Way Galaxy and the location of the Sun within it, and Curtis was correct that the universe contains

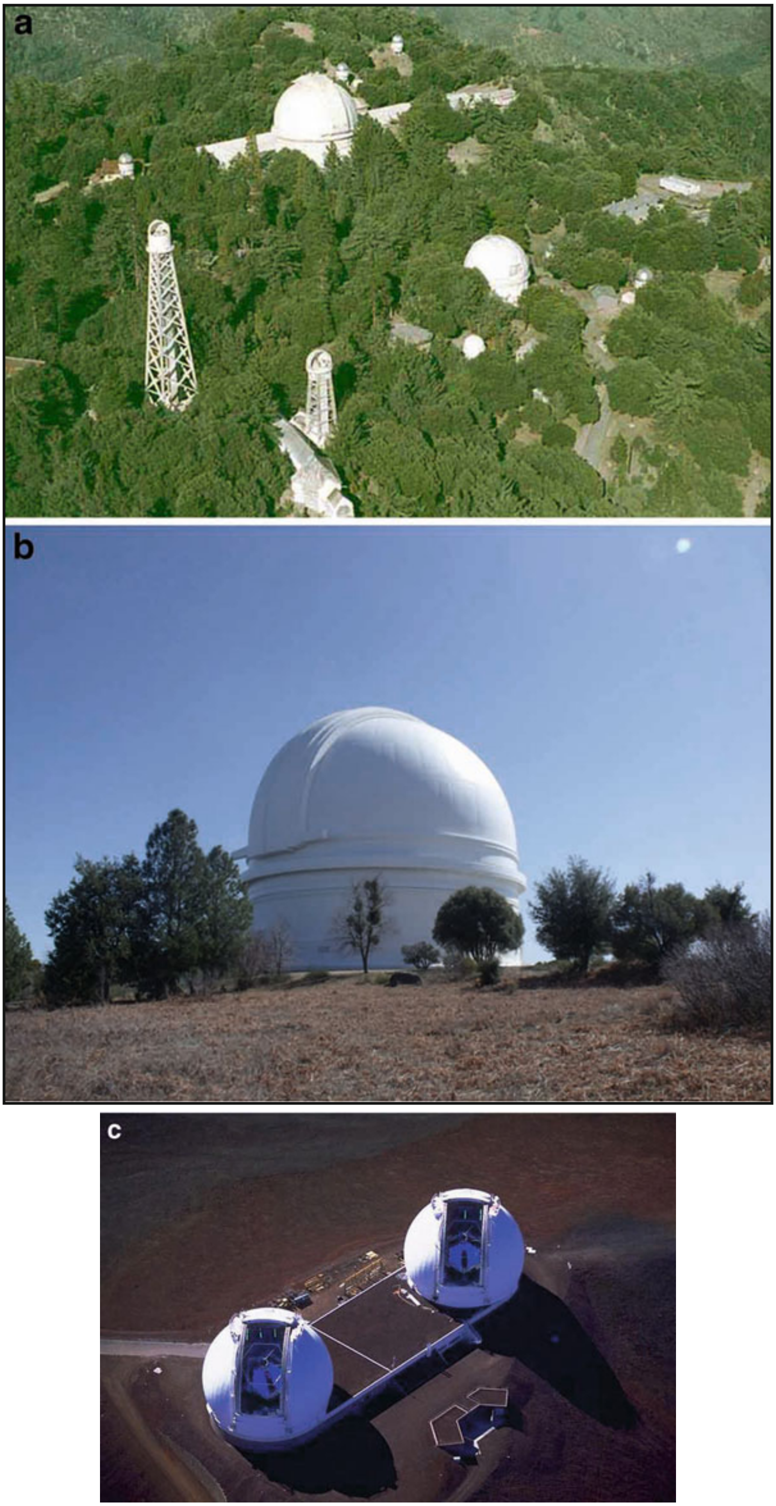

Fig. i.3 (**a**) Images of the Mt. Wilson Observatory, looking toward the 100-in. telescope (aerial view, the larger dome one), (**b**) Ground image of the dome housing the 200-in. Hale telescope at Palomar observatory (Image courtesy of Mr. Scottthezombie of Wikimedia), and (**c**) the twin domes of the 8-m Keck telescopes (Image courtesy of NASA)

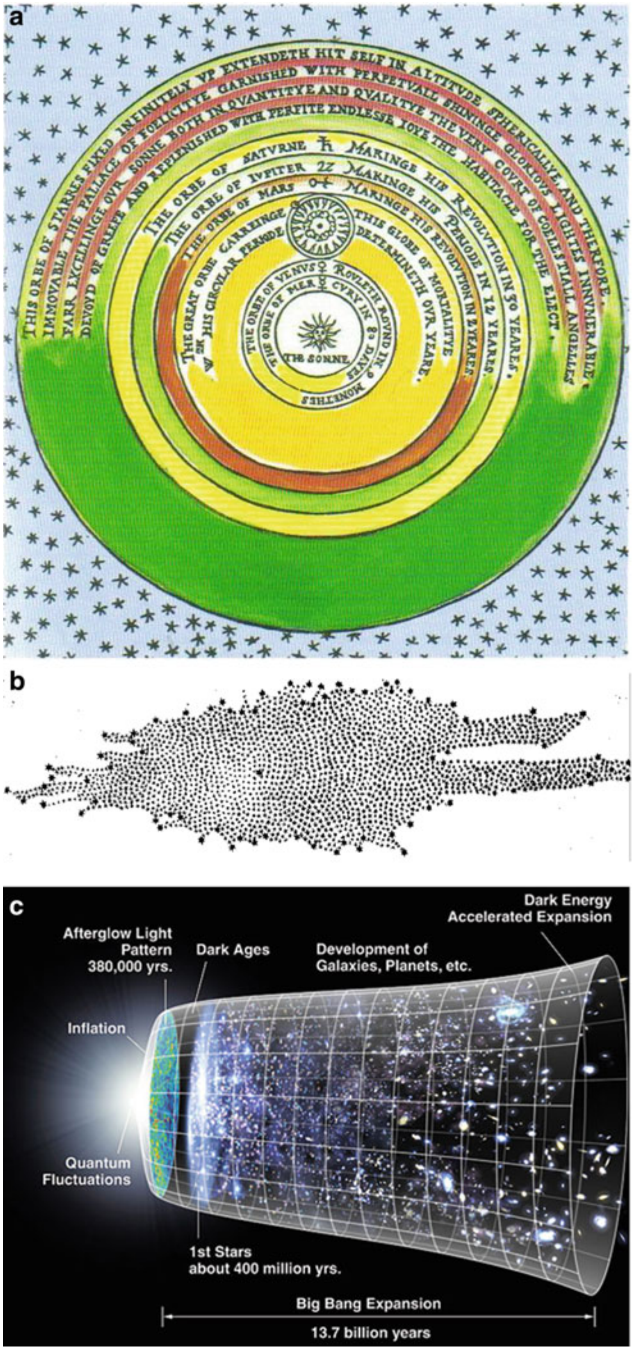

Fig. i.4 Representative images of our view of the universe over the years: (**a**) a model of the Copernican universe by Thomas Digges in 1576, who states that the stars are spread uniformly throughout space outside the realm of the planets (they are not confined to a sphere), (**b**) William Herschel's model of the Milky Way Galaxy based on his observations and research, and (**c**) Early twenty-first-century view of the universe in space and time (All images courtesy of Wikimedia) many more galaxies than our own and that "spiral nebulae" are actually galaxies just like our own.

Back to the telescopes: as 'scopes became larger and larger and techniques and technologies vastly improved (some examples of these are the advent of electronic detectors, the deployment of the Hubble Space Telescope in orbit around Earth, and the use of adaptive optics and interferometry in optical astronomy), the number of known objects, the variety of objects, the dynamics of the universe, and astronomical knowledge in general grew exponentially. With all this development came wider availability of larger telescopes (in the 14-in./35-cm and larger class) to the general public, with monsters 50 in. (1.28 ms) for those with lots of money (It costs the same as a small house in the United States!).

With the developments described above, and the availability of affordable electronic equipment and excellent techniques to the general public, amateur astronomers are producing results comparable to professionals just a few "short" decades ago. In effect, equipped with larger telescopes, better optics, and enhanced observing techniques, amateurs are able to "see farther" than ever before. With these advances, more and more of the universe has become available to the general public. Unfortunately more and more of the universe is becoming hidden by expanding domes of light pollution blanketing the world's cities, rendering faint objects invisible or difficult to see at best. This increase in light pollution that comes with development threatens to make observing faint objects visually more and more difficult as we move deeper into the twenty-first century.

Having shared all this, we ask the question: "Why observe faint objects at all?"

Finding and observing faint objects bring a certain level of satisfaction to those who pursue them for these reasons, most of which will be explored in more detail throughout the book:

- Faint objects gives the observer an opportunity to see what few amateurs get to see (either through their own effort or through other people's 'scopes).
- Faint objects give the observer the opportunity to see deeper into the universe than their colleagues.
- Faint objects greatly increases the inventory of objects that one has seen, to include more unique objects (such as quasars and BL Lacertae objects) than many amateur astronomers have seen in their entire observing "careers".
- Faint objects provide a measure of satisfaction of hunting and viewing challenging objects (the thrill of the hunt).
- Faint objects enable the amateur astronomer to hone and master fine observing skills. These fine skills will help the same individual better see fine details in brighter objects as well as the improved ability to pick out other types of faint objects such as comets.

There are other reasons that astronomers (including you, the reader) who like to go deep would probably include here in addition to these listed.

The bottom line is that, in many cases, observing faint objects connects the astronomer with light that has traveled through interstellar or intergalactic space for up to hundreds of millions or even billions of years. As a result, we are witnessing directly the history of the universe: we see objects as they appear thousands, millions, hundreds of millions or even billions of years ago. So astronomy not only involves a look at distant objects in the universe but also a look back in time, at the history of this same universe.

In the pages that follow, we will sample some challenging open and globular star clusters, planetary nebulae, emission and reflection nebulae, and galaxies. A few quasars will be thrown in for good measure as well. We will cover distant parts of our galaxy as well as distant parts of the universe. A few nearby but small objects will be included also, such as dwarf galaxies and low surface brightness planetary nebulae.

Part I of the book covers the physical nature of these selected objects. What are star clusters? What are planetary nebulae? What is the difference between an emission and a planetary nebula? How are surveys conducted, and how have these objects been discovered? Who has been instrumental in bringing these objects into the realm of the known universe? These will be investigated in the first half of the book. Toward the end of the first half, we will consider why the objects are so faint to begin with and what the significance of their faintness is. We also consider how all these objects may be related to one another. The first half of the book ends with a brief overview of some of the cutting-edge observatories and surveys that continue to hunt for ever fainter and farther objects.

Part II goes into detail about the practical side, the "how to" of observing faint objects. The requirements or prerequisites for viewing such objects are laid out, to include a telescope with at least a 10-in. aperture; access to very dark skies; choosing the best, most transparent and moonless nights to go observing; the proper use of filters; and the maintenance of the equipment. These are described in more detail in Chap. 7, which includes in-depth discussions of the above ideas, plus observation planning that maximizes what often is precious little dark sky time. A balance between quantity and quality is recommended; that is, viewing significant numbers of objects but taking the time to enjoy the uniqueness of each object. Near the end, in Appendix A, we will also feature some software programs such as *Sky Tools* that assist in planning, executing, and documenting an observing session.

After having selected the site, prepped the 'scope, made the observing list (whether with pencil and paper or with the aid of your favorite software), and secured favorable weather with the Moon out of the way, now is the time to get down to some serious observing business. A selection of projects to get you started will be listed, beginning with the projects that the Astronomical League provides for intermediate observers. The "Herschel 400" list is a great place to start and provides a warm up for even fainter objects. Then object types will be broken down by discrete groups (nebulae, clusters, galaxies) and groups of objects themselves, such as Hickson and Arp, and links to information about these and other surveys will be provided. Some suggestions on how to best record what one sees will be given. We do not stay in the Milky Way but include nebulae and star clusters that can be seen in other galaxies.

There are literally hundreds of thousands of objects (the vast majority of which are galaxies) available for observation to one equipped with, say, a 17.5-in. (44.5-cm) telescope; that number swells to the millions (again, almost all galaxies) for people with 36-in. (91-cm, and larger) 'scopes. Although it is nearly physically impossible for an individual astronomer, by himself or herself, to observe all of these objects visually, one can try for as many as one can get and appreciate the ones that he/she does see. In Chap. 10 is a catalog of over 700 representative objects as well as information on where to find additional lists (this in Appendix C), and share the author's personal observations of a sample of these objects.

Finally we explore some ways that, once having started your quest for faint objects, you can stick with this and help you to keep going for the long haul. This is covered in Chaps. 11 and 12, along with some ways that you can make your observations scientifically useful. Resources available to help find variable stars and supernovae are provided and how to estimate their magnitudes. Also described is “Citizen Science” and many ways that the reader can help with actual scientific research, from making careful visual observations to using your PC’s idle time to help analyze lots and lots of data. Things wrap up with a conclusion that puts all of this together and outlines a typical observing run (at least what is typically encountered, which encompasses several areas of astronomy, including faint objects).

Acknowledgments

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