

Publication prospectus

Lonely Planet's Guide to Nearby Planets

Alternative Titles: Rough Guide to Nearby Planets; Meet Your New Neighbors: A Rough Guide To New Planets

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Overview

Every night, millions of us take a moment to peer up at the starlight in the night sky, to let our childhood imaginations run, and to ponder the stars we see. Astronomers, using observations taken well into the 21st century, analyze the compositions and atmospheres of planets in orbit around many of those stars we see with the naked eye.

THE LONELY PLANET'S GUIDE TO NEARBY PLANETS is the first book to detail the physical, tangible characteristics of *individual*, nearby planets and planetary systems. This is not a book about scientific technique, per se, but a book for millions of curious non-astronomers to gain a sense of the physical identity of these new planets and the geography of the Solar Neighborhood.

The book contains sixteen chapters, each focusing on a unique planetary system that exemplifies a new breakthrough in the field. Broadly, the book will be divided into two sections. In Section One, the chapters emphasize the structure of planetary systems, their implications for our notions of a solar system, the methods by which planetary systems can be identified, and the geography of where and how astronomers are looking for them in the night sky. In Section Two, the chapters take our pictures of planets from pinpoint components of solar systems to planets rich with atmospheres, composition, and weather, and dynamic planetary systems.

Each chapter will contain a naked-eyed sky map highlighting the location of the host star with simple instructions to locate the star throughout the year (April 1st, May 1st, etc). Each chapter will also contain an illustration of each system, including orbits, a stat sheet, and factoids (much like a baseball card might). The use of data

and jargon will be presented for illustrative purposes or humor only and without formulae, relying instead on concrete and tangible language, analogy to everyday experiences, and basic astronomy. The tone will be one of excitement, conversational anecdotes, humor, and fun. Personal anecdotes, boots-on-the-ground perspectives, challenges, stories, and rivalries among researchers and groups will be highlighted. The layout is intended for readers to easily jump between chapters and to read for 15-20 minute stretches.

The chapters, collectively, will draw the reader through a narrative touching upon historical context and highlighting the rapid and recent rise of exoplanetry. By the end of the book, the reader will understand the major discoveries since 1995 and anticipated through 2016. The book will be 55,000 words, and contain a bibliography, illustrations, and an index. The manuscript will be completed six months after receipt of the advance and agreement of terms, and will contain cutting-edge results publically available up to the date of completion.

Marketing

This book will be written to appeal to anyone curious or intrigued by the discovery of new planets, their implication for our place in the universe, and the eye-on-the-sky but boots on the ground anecdotes and adventures of planet seekers. All that is required is a free sense of wonder, and a middle school understanding of astronomy. This is literally millions of readers who can pick up this book to be entertained and to learn.

Secondary Markets

This book, because of its educational nature, is an ideal addition to libraries and schools, and suitable for high school summer reading programs. The pick-up and go reading of the book makes an excellent read for commuters and travelers, and those interested in current events in science. Teachers of K-12 who want to understand, develop an appreciation for, and find experiences relatable to planets can take the material into the classroom.

Promotion

In preparation for the publishing of this book, I am prepared to develop a comprehensive promotional platform. In addition to traditional promotional methods, I am in a unique position to develop a fully comprehensive platform.

I will make myself available for radio and television, and send press releases to major magazines about my work. My professional career as an astronomer takes me to universities and large conferences (>3k attendees) several times a year, at which I will promote my book. I manage the Cornell University Ask an Astronomer website (see About Me) section, which receives *6000-7000 unique viewers per day*, and I will promote the book on this site. In addition, I will make myself available to

give public outreach talks at K-12 high schools and colleges, where I am able to promote the book.

Competing Books

STRANGE NEW WORLDS by Ray Jayawardhana (Princeton University Press 2011) broadly discusses several early planet discoveries, but focuses on broad descriptions of techniques, in the aim of provoking a discussion of finding habitable worlds like Earth; no results beyond early 2009 are included. My work focuses specifically on new research, which includes landmark results of the Kepler Space Telescope, the first complete census of nearby solar systems, and the first observational results of composition and atmospheric studies of the most heavily observed exoplanets.

EXOPLANET ATMOSPHERES by Sara Seager (Princeton University Press, 2010) is the first academic text addressing atmospheric processes on new planets, and is intended for researchers in the field.

About the Author

Dr. David Bernat is an astrophysicist and teacher at Cornell University. As a graduate in Physics from the California Institute of Technology (BS '02) and Cornell University (PhD '11), David Bernat has written several academic papers, many on the development of a novel technique to image Jupiter-like planets in orbit around nearby, young stars. He has collaborated and written scientific proposals with numerous teams of planet seekers across the field. These include proposals with the Kepler Telescope Science Team; members of the Microlensing OGLE collaboration; and the research team of the California Planet Survey, discoverers of roughly half the known planetary systems. His work with the California Planet Survey has contributed to the characterization of the HD126614Ab system, a planet one-third the mass of Jupiter orbiting a star in a double system.

Sharing his enthusiasm for scientific adventure has always been a focus of Dr. Bernat's career. He writes for and maintains the popular Cornell University Ask an Astronomer website, offering non-astronomers a place to correspond with astronomers on planets to galaxies to careers. This site receives more than five thousand visitors a day and has been covered by CNN. David is currently writing and directing a new Ask an Astronomer Podcast series. He has previously written for the Cornell Chronicle on topics of the physical sciences and finance. Dr. Bernat is enthusiastically seeking a publisher to publish a new book on the exciting scientific adventure to discovery and characterize new planets.

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Chapter-By-Chapter Summaries

- 1) Kepler-10b: Strange New Worlds

There is no better indicator of the exponential rate of advancement in the field than the Kepler Space Telescope. After four months of its ongoing three year mission to find Earth-sized planets with liquid water, astronomers have discovered more than a thousand new planets, including sixty-eight Earth-sized planets, six with the potential for liquid water, and the first confirmed rocky exoplanet: Kepler-10b.

Kepler-10b is a molten mass of iron twice the size of Earth with three to eight times its gravity. Announced in Jan 2011, this planet is an example of planet discoveries at the front edge of exoplanetry. From this point on, and as the volume and precision of observations increase, astronomers will finally expand beyond the discovery of planets' existence, and begin talking about the tangible nature – composition, atmosphere -- of individual planets.

- 2) 51 Peg b: & 70 Virginis b: Turning a star red to blue and back again.

Just eighteen years ago, then high school students like me learned that if other planets existed around these stars, then our nine-planet solar system must be the boilerplate for those worlds. The science community considered other worlds to be silly speculation or serious madness, either engraved gold-plates on the Voyager spacecraft or the stuff of science fiction-infused E.T. searchers.

The discovery in 1995 of the first new planet outside our solar system– Peg 51b: a Jupiter-size planet, scorchingly hot and orbiting its star eight times closer than Mercury does our own – shattered the boilerplates and rushed the scientific community into the era of exoplanets.

But astronomy is the largest game of seek-and-find in the universe. Unlike most sciences there are no ‘experiments’ in astronomy – one cannot poke a star to see how it reacts. One must point the telescope skyward and hope to capture the rare and unexpected. And yet, from those pinpoints of light astronomers have inferred nearly everything we know about the universe.

There are as many motives driving the planet seekers as there are planets being discovered. Geoff Marcy, before he discovered seventy of the first hundred exoplanets, stood in the shower one morning sure his young career was going down the drain. But believing he was failing, a freedom was born. In a last ditch effort, and with his remaining resources, he sought to answer the one question that he’d always wanted to know: Do other stars have planets? His colleagues were embarrassed for him. Looking back, he calls the endeavor ridiculous.

The fascinating discoveries of Peg 51b (by Mayor and Queloz) and 70 Virginis b (by Geoff Marcy et al.), and their path to acceptance against the prejudices and skepticisms of the community remains relevant. The technique of its discovery (radial velocity), which had been the most fruitful until the release of the Kepler Telescope results, is described so that the reader understands the physical and technical challenges astronomers overcame to find Peg 51b and 70 Virg b. For nearly a decade after its discovery, planets like these overwhelmed the planet tally, and painted a picture of other solar systems looking nothing like our own.

3) HD 209458b: Things That Go Blip In The Night

The news came in an email: “Call me immediately. We need to talk.” For most recipients, the words might be cryptic or dreadful, but Tim Brown knew exactly what had just happened.

Despite two dozen detected planets by 2000, many hold-outs in the science community still doubted the existence of exoplanets. No one had a good explanation for how Jupiter-sized planets could orbit so close to their star. Decades of studying our solar system and its bodies – which looks nothing like these new planetary systems – left its mark. And every previous planet had been inferred using a single method. It’s easy for even the most optimistic astronomer to doubt what you can’t see.

A new kind of exoplanet discovery was about to be made. Inevitably, some of these new found planets – large, and orbiting close to the star – must orbit in just such a way as to periodically block our view of the star. In essence, astronomers wanted to catch an eclipse happening in another solar system. Even more important than providing a confirmation that astronomers had been detecting new planets, mastering this method of detection would lead astronomers to begin decoding the composition

and atmospheric chemistry of these new planets. HD 209458b presents the backdrop for one of the most exciting races-to-first-discovery in astronomy.

Two teams of researchers undertook the challenge – one using a 4-inch telescope in a parking lot in Boulder, Colorado, one using an automated observatory in Arizona. Each team was being quietly fed the newest, unpublished, private radial velocity planet detections from other colleagues also invested in finding planets.

When Tom Brown scanned those words in an email from his challenger, he knew what to do. It was time to pull together whatever data he had: news of a new detection was breaking.

HD 209485 is the most heavily observed exoplanet, with over two hundred academic papers written on the planet. Less than two years after the detection of HD 209485b, one of these teams went on to detect chemical elements in the atmosphere of this planet, 150 light years away. The story of its detection brought the scientific community to a consensus, and is a fascinating portrayal of the behind-the-scenes process in which professional relationships, shared interests, and competitive collaboration drive discovery before the news reaches press.

4) You're Already Here: A Brief Guide to Viewing Our Galaxy From the Inside

You'll think it's one of those knucklehead questions, but it's a revealing one: How many of these new planets are in our Galaxy? Nearly everyone I talk to eventually, sheepishly, asks this question. And why not? Astronomy yields so many fantastic discoveries that it lose sight of the possible and impossible and easy to forget these objects are somewhere above us in the night sky.

Surprisingly, every planet search has taken place in a tiny bubble of stars near our sun, our Solar Neighborhood, just 0.1% the size of the Milky Way. But we have learned the road signs of our neighborhood well: nearby pockets of ongoing star formation, stars in the night sky which trace back to a common birth origin, the location of stars like our sun, hundreds of stunted stars which straddle the line between planets and stars. The search for new planets has brought a renewed interest in understanding stars, and each kind of star carries unique advantages and challenges to planet searches. But for us, knowing our neighborhood puts the current exploration for new planets into a global perspective.

With simple diagrams and state of the art science, this chapter will present the reader with a map of our Solar System, our Solar Neighborhood, the location of current planet searches, and place these landmarks in the context of the galaxy from two perspectives: viewing the galaxy top-down and as observed from the Earth.

5) GJ 581b-g: Astronomers Cry Wolf of a Goldilocks System

Want to rile up a crowd of exoplanet astronomers? Mention GJ 581g. Want to see a media frenzy? Mention those three big words: Habitable. Zone. Planet.

Finding a rocky planet with liquid water on its surface – a “habitable zone planet” -- is still the holy grail of planet searches. A system true to its Goldilocks

nickname, the GJ 581 system first received attention in 2007 upon speculation that the outermost planet GJ 581c may be temperate for liquid water. The dreams of every exoplanet astronomer who hopes to identify the first habitable planet froze for a moment that day. In the following months, theorists claimed the planet suffers a runaway greenhouse affect like Venus, making liquid water impossible. It's too hot.

Then in 2009, climate models suggest its outer brethren GJ 581d, initially thought to be too cold, could have water. It's certainly the smallest planet discovered, but is it a water world? The news media outlets propel the story. The website Bebo uses a Ukrainian telescope to beam radio messages to the system. Astronomers, one-shy don't want to be twice-bitten. And every speculation sensationalized threatens to give the public a misperception of the science. Astronomers find it tantalizing, but the entire question rests on some very uncertain science needed to predict the climate of an entire planet hundreds of light years away. GJ 581c seems to be too cold. Or, in the words of the astronomer who detected it, it could have "large and deep oceans."

Then the Big News comes again in Sept 2010: the discovery of a fifth planet, GJ 581g, orbiting right smack between too-hot 'd' and too-cold 'c' - only thing is, a rival observing team concludes GJ 581g doesn't exist! News outlets misreport of concerns of "manipulated" data; an independent astronomer analysis concludes there's no planet, but other researchers call aspects of the analysis "odd." The astronomer behind its (potential) discovery, Steven Vogt, believes it is a true Goldilocks system and is quoted to the New York Times saying "The chances of life on this planet are almost 100%." Other astronomers snicker and call it the Boy Who Cried Wolf system.

In the words of one colleague: "be careful [describing GJ 581] - we still don't know what is going on here." This chapter presents the drama of GJ 581 and the huge rewards, huge stakes, the huge uncertainties in searching for habitable planets. In preparation for discoveries presented in this book, the reader will also gain a sense for what is science fact and what is sensationalism in this new era as scientists begin characterizing the worlds they detect.

6) HR 8799b-d and Formalhaut B: Dusty Snapshots and Baby Pictures

When was the first time you went out into your backyard to see that reddish-brown dot in the night sky that you had learned was Mars? All those mysterious canals, the reddish soil, the two Mars rovers Opportunity and Spirit, the "Face on Mars." There's something about seeing the planet in the night sky that makes it more real than be told its true.

Only two years ago (2009), we snapped the first pictures of another planetary system - complete with newborn planets, dust belts, and an analog of our own system's Kuiper Belt. With this vantage point, the processes of planetary formation can be seen in these pictures. Paul Kalas, its discoverer, called it profound and overwhelming: "I nearly had a heart attack." He had been trying to image the planet for eight years.

And Jupiter-sized planets keep popping up in weird places. Early planet searches found Jupiter-sized planets on extremely small orbits; these images show Jupiter-like planets forming in the far reaches of solar systems (many times further than poor, icy Pluto). Astronomers had good reason to believe that couldn't happen.

Unlike radial velocity and transit detections, the capability to image a planet gives astronomers stark visual information about the early life of solar systems, and speaks to many of us on a more personal level. Who'd have ever thought we'd be witnessing the birth of solar systems with our own eyes?

These planets and systems are very different from any others discovered, and informs the entire pursuit of searching for planets. Maybe it answers the question: Mix up the debris left after a star has formed, and what kind of planets can shake out?

6) WASP-12b: Viewing Another Solar System's Planetary Eclipse

NASA has launched a full-scale operation to detect new planetary systems. The Hubble Space Telescope and Spitzer telescope are routinely used to observe planetary systems. The largest observatories in the world devote substantial time to this endeavor. Yet in a workspace as large as sky, there's plenty of room available for the upstart astronomers.

After the first successes of HD 209458b, dozens of small projects sprung up using many small telescopes to stare at the sky searching for transits of nearby stars. Counter to the large programs surveying for planets, these projects were created to be inexpensive, sometimes with off the shelf camera equipment, and often operated by one or a few members of the team. Like any start-ups, many of these failed and only their tails of dashed hopes remain. Two have succeeded, and are producing big discoveries along the way.

Gaspar Bakos began building HATnet as an undergraduate student in Hungary. He endured instrument failures and long, cold nights transporting his telescopes to its observatory in Arizona. Another program, SuperWASP out of the UK, has detected nearly fifty planets, including WASP-12b, a planet so close to its star that it's stretched into a football.

One of these is the large football-shaped WASP-12b. The last year has seen incredible efforts to identify the weird structure of this planet, and the large cloud of gas it seems to travel in. Certainly, the gases surrounding WASP-12b are being leeched off its atmosphere by the star. In the words of a NASA press release, the group has found "a star eating a planet."

7) OGLE-2006-BLG-109: A Truly Serendipitous Alignment of the Stars

Now that Astrologers have hundreds of new planets to incorporate into their starcharts, I challenge them to decipher the cosmic significance of this: Two stars, far separated in different parts of the Galaxy, floating along as they have for billions of years. By happenstance they align, i.e., they overlap in the sky, and to the observer the background star appears to brighten a thousand-fold. It's pure science-fact, and if the foreground star harbors a planet, astronomers can tell.

With the help of a global network of amateur astronomers, patches of sky are monitored to find these rare alignments; the rarity of the alignment is matched only by sheer number of stars in the Galaxy, and this group finds a lot of planets, including rocky Earths. But the fortunes are truly serendipitous: the alignment lasts only a few days or weeks, and the planets are nearly impossible to restudy when the alignment breaks.

OGLE-2006-BLG-109 harbors two outer (cold) gas giants, analogs to the Saturn-Jupiter our solar system. Its host star can still be found floating by.

8) Kepler 11b-g: A Watershed Moment in the Search for Wet Planets.

The Kepler Space Telescope revealed not just one thousand new planets, but sixty-two Earth-sized planets and six which may have liquid water on their surface (Feb 2011), and one with a molten iron surface (Chapter 1, Dec 2010). It is the first mission specifically designed to discover dozens of planets with the potential for liquid water, and the results are pouring in. As the KST continues its three-year mission, it will find continue to find planets, including small rocky planets on Earth-like orbits. How many rocky planets are out there? The KST mission will find out.

Kepler 11b-g do not likely have rocky surfaces, nor liquid water, but the six planet system is one of the best examples of how Kepler is moving the field of exoplanets away from Hot Jupiters and towards an incredible array of planetary types unlike anything we have ever seen in our solar system or elsewhere. Kepler reveals unexpected surprises on monthly timescales. The reader will be presented with the assortment of planets Kepler is finding as an introduction to the new forms of planets being discovered, and their implications for the composition, atmosphere, and habitability of exoplanets. Specific examples of the composition, atmosphere, and habitability of exoplanets will be covered in the next section. The contents of this section are very likely to evolve up to the date at which the manuscript is finished.

Section 2: Pinpoints to Planets

Taking our picture of planets from pinpoints of mass to planets rich with atmospheres, composition, and weather, and dynamic planetary systems.

9) HD 189733b: Emissions Tests: What's in the Atmospheres of Exoplanets?

10) GJ 1214b: A rocky Earth? An icy Neptune? A stunted Jupiter? – A Composition on Composition

The era of exogeology is upon us. The recently discovered ‘Super-Earth’ GJ 1214b (late 2009) is an Earth-sized rocky planet of too low density to be composed of rock and iron alone. A pure water ice world is ruled out. The planet must have a rocky core and thick gas layer; it’s nothing like the planets of our solar system.

Relying on observation data, several research teams conclude that GJ 1214b is composed of one of three types of material. GJ 1214b could be a gas-giant reject, an almost-Jupiter-like planet which had its formation shunted before it grew larger than the size of Earth. GJ 1214b could be warmed ice-dwarf, a “bigger, hotter version of Jupiter’s icy moons” with a thick atmosphere formed by the sublimation of ice off its surface. Or, GJ 1214b could be a planet of rock, in which subterranean gases erupt from beneath its surface. There are three specific scenarios of composition and atmosphere. The answer to the composition question floats above the surface, in the chemistry of its atmosphere, and observations are underway.

Using this planet, the reader will be introduced to various stages of planet formation, and the teams of researchers who have led to this discovery. It will also answer the question, What can the atmosphere tell us about the surface of a planet? [O,P]

Traditional planetary scientists – the greats who discovered water on Mars – struggle to make sense of the exoplanet. Consider a geologist.

11) HD 209458b/HD 80606: Tonight’s Forecast: High Winds

12) HR 8799 and Formalhaut Revisited: “That solar system shouldn’t exist!”

New images of HR 8799 reveal a fourth gas-giant planet that “should not exist” according to the two well-established theories of planet formation (Nature, Dec 2010). The Gemini-Planet-Imager, a super sophisticated imaging camera to come online in mid-2011, will yield “droves” of images like these.

13) All In The Family: A Brief Census of the Solar Neighborhood

The first census of our Solar Neighborhood is complete: Among the findings, twenty percent of stars harbor close orbiting Earth-sized planets (like Mercury)(Dec 2010), most common are Neptune-sized planets, and multi-planetary systems are the norm (March 2011). This chapter reflects on what this means for our notions of a solar system, answers the question as to whether ‘hot Jupiters’ like Peg 51b are really the norm, and discusses the changes to future searches for planets, including potentially “habitable” planets, that are motivated by this finding.

14) HD 10180: It’s a Wonder Earth Lasted This Long!

This solar system is already conspicuously overcrowded. With five planets the size of Neptune or smaller, the HD 10180 system is the one of the most fully packed

solar system architectures outside of our own. And, like most solar systems, each planet undergoes a careful balancing act: move one planet out of place, and the entire system rattles and another gets kicked out of the system. New multiple-planet systems need to remain stable long enough for us to spot them.

This obvious fact is allowing astronomers to determine the physical properties and formation histories of these planets, the role of general relativity and planet-planet interactions over the lifetime of the system, and may give us the first definitive answer as to why so many solar systems look nothing like our own.

15) HAT-P-6b and WASP-17b: The Seconds Hand Ticks Counter-Clockwise

The last two years brought another unanswered question. Against all common wisdom, astronomers have started observing close-in Jupiters with retrograde orbits – they orbit the star in a direction opposite their outer companions. This implies these planets undergo an unknown, but violent shake-up at some point in their history; and that these shake-ups are a fairly common.

Example Book Cover:

Meet the
New Neighbors:



First Contact with
the New Planets
in Our Solar
Neighborhood