Understanding a Scientific Paper

The purpose of the assignment is to introduce you to a scientific paper:

"Discovery of a Candidate Inner Oort Cloud Planetoid"

This is the discovery that started Pluto on its course to being stripped of its planet status by the International Astronomical Union in 2006. In this paper, researchers describe how they discovered Sedna, an object comparable in size to Pluto and more distant from the Sun. They explain how it orbits around the Sun and they hypothesize on how it got to be where it is, which puts Sedna in the context of our solar system. (Note that the paper is from 2004, and therefore some of the statements made within it are now out of date.)

How to read a scientific paper

Most scientific findings are written to be published in journals and are referred to as "papers." A scientific journal isn't a typical magazine. The papers they contain are written as a means of archiving or storing the information. For this reason, they don't care too much about maintaining someone's interest with a story line. The typical paper writing you've all learned doesn't really apply in a scientific paper.

The first thing to do is realize you will need to read this **paper more than once** to understand it. The information they contain is very compact. Also realize there are some parts of this paper that are simply beyond what you've learned so far – don't worry about the specific methods they mention, especially when discussing error, noise, and uncertainty!

Look at the different sections of the paper. A typical paper has the following layout:

1. Abstract: *This is like a summary. It gives a little background on the topic and summarizes the findings reported in the paper.*
2. Introduction: *This section has the background information necessary for the reader to know what's going on (or at least refers the reader to other papers). It also poses the question the authors are attempting to answer.*
3. Materials and Methods: *This section describes how they went about obtaining their results. It should have enough detail that another researcher could duplicate their work. In this specific case, they discuss their images.*
4. Results: *This sections describes what experiments where done, sometimes it also analyzes or explains the results, most of the time all the analyzing is done in the discussion sections. In this paper, this section is divided into two: Orbit and Origin. The Origin section is written to explain the results*.
5. Discussion: *This section interprets and analyzes the data and explains the sources of error or uncertainty. It may also discuss the implications of the results in the larger context of the field of research.*
6. Sometimes there is also a conclusions section, which summarizes the findings and the interpretation by the researchers.
7. References: *like a bibliography*.

The Assignment

Read the paper a few times, to help you understand it, **answer the questions below as you read.** Look up words that you don't understand that aren't in the glossary. Email or stop by with questions.

Due October 17 by 5pm

Questions

1. In the abstract: Explain what they will show in their paper in your own words.
2. In the introduction: write the first paragraph in your own words
3. In the last paragraph of the introduction: The phrase "a distant eccentric orbit with the object currently near perihelion" says something about how close the object will ever get to the Sun. What does it say?
4. In section 2: "Unfortunately, individual images in the … survey are not taken long enough apart for us to determine if this object is moving or is instead a fixed source that was coincidentally bright only during the time of observation…" What are they talking about and why did they mention this? Hint: If you're totally lost here, email me for a hint.
5. Don't worry about understanding anything from the paragraph "From a 4 month" to the end of the section. They are discussing other possible detections of the planetoid so they can have more data points in its orbit to figure out the details of its orbit.
6. In section 3: How much farther is this planetoid than Pluto? What's the difference between heliocentric distance and semimajor axis?
7. In section 4.1: Explain the sentence "Hogg … objects" in your own words.
8. In section 4.2: What does "perihelion modification" mean? Explain it to someone who doesn't know any science.
9. In section 4.3: Read the first and second sentences carefully. Why would a slow moving star have a larger effect on this type of Oort Cloud object?
10. After reading the paper a couple times, especially the discussion section, explain in a paragraph or two why this discovery (and its interpretation) lead to such a controversy over Pluto's status.

Glossary

This listing does not include terms you can just look up in either online or in a dictionary (like Kuiper Belt and Oort Cloud). Below are words that have multiple definitions and the one you may first come across is not the one that they are using in this context. Some potentially confusing phrases are also explained.

From the Abstract:

Eccentric, eccentricity: A measure (from 0-1) of how oval a shape is, 0 means perfect circle, 1 would mean such a flat oval, it's a straight line. Low eccentricities look like circles to us, but are not centered.

Perihelion, perihelia: The closest point of an orbit to the Sun. The "ia" makes it plural. The opposite is aphelion.

Scattering: This is used to describe a gravitational encounter from one object that changes the orbit of the object(s) in question. (Look up "gravitational scattering")

Perturbation: A little push, a small input of energy, just enough to change the orbit of something slightly. (Look up "gravitational perturbation")

Population: This is a term used like we would use "group of objects that have something in common." For example, asteroids could be a population or young stars could be a population.

From section 1:

Inclination: An amount (usually in degrees) an orbit is tilted outside of the plane of the planets in the Solar System. (Look up "orbital inclination")

Dynamical, dynamically: having to do with moving or movement. "...they are detected as dynamically new comets" could be restated: "we see them move as comets"

Opposition: An object is on the opposite side of the sky as the Sun when viewed from earth. (Look up planetary opposition)

Least-squares method: A way to fit a line, in this case, fit the line that traces out an orbit

From section 2:

"Archival data to extend the time baseline backward in time"
This sentence refers to data that was taken a long time ago and is used to find the planetoid earlier in its orbit.

Error-ellipse: A two dimensional region of uncertainty, that means the planetoid could just as easily be anywhere within that elliptical shape.

From section 3:

rms residuals: "root mean squared" a means to estimate uncertainty in a measurement. You'll learn it in future physics labs.

Robustness: This is a term used all the time in astronomy, You can replace the words "the robustness of" in this sentence with "how well we determined" and get the same meaning.

From section 4:

Migration: When planets seem to move toward the star or away from the star over time. (Look up "planetary migration")

$M_{\oplus}$: Means the mass of Earth

Ecliptic: The plane that all the planets orbit.

Thermalized, isotropic: This is a specific way of describing a certain type of equilibrium. Don't worry about understanding this sentence.

Orbital integrations: Roughly means that they tested many planetary orbits.

Numerical simulations: Computer simulations

FWHM: Full width half maximum, it is a statistical measurement. (don't worry about it now)

Ecliptic latitude: Think of the Sun at the center and the planets filling in space along the equator of a large sphere. Latitude is just like how we measure latitude on the Earth.