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The evolution of a hot Jupiter may differ significantly from that of an otherwise identical planet located farther from its parent star. The atmospheric structure and opacity play a crucial role in regulating the planet’s energy balance and also govern its appearance to the external observer. In this paper we have emphasized on the formation, atmosphere, strange attractions and blow out effect of the best-known ‘hot Jupiters’.

Introduction

During the beginning of the space age, astronomers do not know anything about the planets outside our solar system. It was in 1995 only when the first extra solar planet was discovered which was orbiting a Sun-like star. It orbits the star 51 Pegasi. From the motion of this star and estimates of this star’s mass, astronomers can deduce that the planet has half the mass of Jupiter and orbits only 0.05 AU from the star. Half the mass of Jupiter amounts to 160 Earth masses, so this is a large planet. The planets were named as “hot Jupiters”\textsuperscript{1}. The word Jupiter came because they’re giant planets, even more massive than Jupiter while they are called ‘hot’ as they orbit close to their stars, even closer than Mercury. These planets orbit their Sun every two or three days and having high surface temperatures\textsuperscript{2} between approximately 0.015 and 0.5 astronomical unit (AU) to their parent stars,\textsuperscript{3,4} while Jupiter orbits its parent star at 5.2\textsuperscript{AU} causing low surface temperatures. The purpose of the paper is to focus the formation of “hot Jupiters” with their strange attracting behaviors as well as to examine critically their atmospheres and other mysterious characteristics.

The Best-Known Hot Jupiter

One of the most favorable targets for measuring the structure and composition of an atmosphere of exoplanets is the transiting hot Jupiter HD 189733 b for a number of reasons. When it passes behind the star during secondary eclipse the brightness of the system drops by about 0.5% in the near-infrared region\textsuperscript{5}. Furthermore, with a K-band magnitude of 5.5, the brightness of the host star provides the large number of photons that are required to perform these high precision measurements. HD 189733 b is one
of the targets favorable for planetary atmosphere studies, the other being HD 209458 b which is the first transiting planet discovered.

Figure 1 shows photometric signal (Stellar V magnitude) vs. atmospheric signal. More the planets to the top right, the easier it is to measure their atmospheric features with transmission spectroscopy. The dotted lines show curves of constant signal to noise ratio i.e., S/N. The planets to the right of the top curve have an atmosphere detectable with 90 minute integration (<~1 transit) with the Hubble Space Telescope. The planets to the right of the remaining two lines would have detectable atmospheres if the amount of incident photons were increased by a factor 5 and 10 respectively.

**Formation of “Hot Jupiters”**

According to the theory of solar system formation, massive Jupiter like planets can form outside of the frost region of the star system and have nearly circular orbits. Hot Jupiters, on the other hand, are massive Jovian planets that have highly elliptical orbits. Astronomers believe that planetary migration is one of the explanations for the formation of hot Jupiters. This theory explains that hot Jupiters are formed in the outer regions of their solar system and then migrate inward. This migration is caused by the propagation of waves through the gaseous disk around the young planet. These young Jovian planets get massive enough so that their gravity is strong to clear the orbital path of the gas disk. As a result, the planet creates waves that propagate through the disk, which causes the material to collect at one place. Then this collected material gains enough gravitational force which reduces the orbital energy of the planet causing the planet to migrate inward. Figure 2 shows an image from a numerical simulation of the interaction of a massive planet with a gaseous protoplanetary disk.

Another theory which explains the highly eccentric orbits of hot Jupiters is based on gravitational perturbation. Gravitational perturbation happens when two young Jovian planets have a close gravitational encounter. This counter can send one planet out of the star system while the other planet is sent inward towards the star into a highly elliptical orbit. Another feature of the hot Jupiter is that it is not formed at the place where it appears ultimately but it locates at a much larger distance from the central star. The planet then moved to its current position. Figure 3 reveals an artist’s conception of one of the “hot Jupiter”.

**Atmosphere of “Hot Jupiter”**

The atmospheres of ‘hot Jupiters’ are very unusual. They have very high temperatures of a thousand to several thousand Kelvin, so that at these temperatures the planets could have clouds of molten rock. They are actually more similar to the compositions of relatively cool stars. It is believed that they are tidally locked, which means that one side of the planet is getting all of the heat and the other side is cold. Tidal forces occur when the gravitational force on a side of a large object is stronger than the other side causing the object to stretch. As the hot Jupiters orbit around their stars, the strength and direction of tidal forces change due to the elliptical orbit. This variation causes the planet to be flexed in different directions generating much friction inside it. This friction tends to warm up the planet. Tidal forces have also locked hot Jupiters and their stars into synchronous rotation. A synchronous rotation is one when the rotation period and orbital period of planets are equal; therefore the same side of the planet is always facing the sun. This means that hot Jupiters are rotating rapidly because their rotational period is only a few days long. Figure 4 shows the tidal effect of Earth and Moon.

Astronomers can detect which gases are present in the atmospheres of hot Jupiters by analyzing the spectrum of starlight filtered through the atmosphere of the planet when the planet passes in front of the star. These hot Jupiter planets are expected to have a very different composition from planets in our own solar system like Jupiter, where temperatures at the cloud tops are around 150 degrees Celsius. However, the first hot planet observation shows an unexpected absence of titanium oxide. But, current 3D models of hot Jupiter atmospheres propose that small part of this heavy molecule should be circulated by fast winds which may allow gaseous titanium oxide to reach the upper atmosphere. If the gas is not detected, then it may suggest that either the winds are not as strong or the molecule is forming much larger parts that are too heavy be lifted. Thermal gradients in hot Jupiters drive winds at the rate...
of 6000 mph which in turn carries suffocating heat around the globe. The blue color of the planet may be caused by silicate particles in the atmosphere of the planet, which scatter blue wavelengths of light from the parent star.

Figure 5 shows the temperature variation of hot Jupiter. It appears from the figure that star-facing side features a daytime temperature of 2,127 degrees Celsius, while the night-facing side experiences a temperature of 927 degrees Celsius. So even at night, this planet is ten times hotter than Jupiter.

**Detection of Water Vapor in Hot Jupiter:** Researchers have used a new technique to analyze the gaseous atmospheres of exoplanets and have made the first detection of water in the atmosphere of the Jupiter-mass planet orbiting the nearby star Tau Boötes\textsuperscript{13}. Figure 6 shows simulated data for the method used for detecting water vapor features detected around the hot Jupiter Tau Boötes b.

![Figure 6](image)

The figure clearly shows that planetary signal has been increased in strength by several orders of magnitude relative to the actual signal. The dotted lines show the blue and red-shifts of the planetary and stellar lines in the data, respectively.

The method utilized the radial velocity (RV) technique. This technique commonly used in the visible region of the spectrum for discovering non-transiting exoplanets. Using the Doppler effect, RV detection traditionally determines the motion of a star due to the gravitational pull of a companion planet. The star moves opposite that of the orbital motion of the planet and the stellar features shift in wavelength. A large planet or a planet closer to its host star provides a larger shift. This RV technique was expanded into the infrared to find the orbit of Tau Boötes b around its star and added further analysis of the light shifts via spectroscopy. Since every compound emits a different wavelength of light, this unique light signature allows the researchers to analyze molecules that make up the planet’s atmosphere. Using data of Tau Boötes b from the Near Infrared Echelle Spectrograph (NIRSPEC) for comparison the molecular signature of water to the light spectrum emitted by the planet, confirming that the atmosphere contain water vapor\textsuperscript{14}.

However this current state of the technique cannot detect Earth-like planets around stars like the Sun. Future telescopes such as the James Webb Space Telescope and the Thirty Meter Telescope will enable us to examine much cooler planets that are more distant from their host stars and where liquid water is more likely to exist\textsuperscript{14}.

**The Strange Attraction of Hot Jupiters**

Sizzling gas giants circling close to their host stars keep them young and active. Hot young stars are wildly active and emit giant, violent flares as well as huge eruptions of charged particles from their sizzling surfaces. This bright emission is assumed to arise from intense magnetic fields driven by their rapid rotation. As stars become aged they naturally become less active, their X-ray emission weakens and their rotation becomes slow\textsuperscript{15}. Astronomers have theorized that a hot Jupiter circling extremely close to the host star’s surface might be able to sustain this activity. If the planet is orbiting faster than the star rotates, it will transfer angular momentum to the star. This will inhibit a star’s spin-down causing it to continue rotating rapidly and hence appear young even while it ages. Binary systems have been used for examining only one star known as exoplanet. Both stars in a binary system are expected to be the same age. So if the star with the hot Jupiter gives off more X-ray emission than its twin, there is no doubt that its added youth is triggered by the planet’s involvement. Figure 7 shows an artist’s conception of a hot Jupiter circling an active star.

**‘Hot Jupiter’ Exoplanets Aren’t Eaten by Their Stars**

It has been found that huge, burning-hot alien planets when come close to their parent stars they are not being consumed by them. The inward migration of the hot Jupiters tends to halt before they spiral down to their end. As a matter of fact, all hot Jupiters get closer and closer to their stars but this process stops before the stars get too
Figure 2 Numerical simulation of the interaction of a massive planet with a gaseous protoplanetary disk.

Figure 3 Artist’s conception of one of the “hot Jupiter” [http://www.universetoday.com/109269/what-are-hot-jupiters/]

Figure 5 The temperature variation of hot Jupiter (Image credit: Nikole Lewis/MIT)

Figure 7 An artist’s conception of a hot Jupiter circling an active star (Image credit: NASA/CXC/M.Weiss)

Figure 8 The inward migrations of “hot Jupiter” exoplanets stop when their orbits are circularized by their parent stars’ gravity

Figure 9 Artistic impression of blow out effect of hot Jupiter (Credit: NASA)

The planets mostly stabilize once their orbits become circular, whipping around their stars every few days. Figure 8 exhibits the inward migrations of hot Jupiter exoplanets obstruction when their orbits are circularized by their parent stars’ gravity.

**The Blow-Out Effect**: All hot Jupiters atmospheres are blown out on account of the intense solar winds. NASA’s Chandra and the ESA’s XMM Newton chronicled
HD189733b as it transited its star, detecting a drop in X-rays three times deeper than the corresponding decrease in optical light. This would imply an atmosphere of absolutely large. Photograph 9 reveals an artistic impression of blow out effect of hot Jupiter. Sometimes, a hot Jupiter will get smashed by an intense stellar flare.\(^{17}\)

**Conclusions**

Overall the prospects for direct observational study of the physical properties of the hot Jupiters appear extremely promising. The process of formation and evolution of these planets will be invaluable in the search for systems with properties more similar to those of our own solar system.\(^{18}\) Furthermore, many of the techniques pioneered in studying the hot Jupiters will surely come in useful again a few more years down the road, when space-based interferometers, coronagraphs and ground-based telescopes of 30 to 100 m aperture bring the characterization of terrestrial exoplanets within our grasp. At the same time, new optical and infrared spectral separation techniques will uncover the role played by the chemistry and physics of irradiated gas-giant atmospheres in regulating their cooling and contraction.

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