# 7 evidences of periodic bursts of stars and planets in their youth

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**Abstract**: Based on the idea of Fred Hoyle that matter burst from the Sun formed planets, raise the theory of periodic bursts of stars and planets in their youth and provide a simple self-consistent model to explain many facts of the solar system and other planetary systems. Prove the theory with 7 evidences. First, the recently confirmed hot Jupiter V 830 Tau b orbiting a 2-Myr-old solar-mass T Tauri star was born from the burst of the star. Second, the similarity and differences of the architectures of the planetary system of Kepler-90 and the solar system was explained systematically. Third, the composition and low mean densities of the jovian planets which are similar to that of the Sun mean that they were once parts of the Sun. Fourth, parent bodies of meteorites from asteroids cooled down and solidified without or with differentiation from the temperature of the photosphere of the Sun. Fifth, widespread liquid water and valley networks on Mars about 3.7 Ga ago mean Mars was at the present orbit of the Earth or closer to the Sun at that time. Sixth, ancient rocks of the Earth and the Moon recorded solar wind 10 million times stronger than it is now. Seventh, regular satellites were products of bursts of planets in their youth.

**Key words** stars, Sun, planets, exoplanets, satellites

## 1. Introduction

Though complex models such as gas drag and type-II migration were invented and developed, we still lack a self-consistent theory for the origin of the solar system and other planetary systems[1]. Based on the idea of Fred Hoyle (1915-2001) that matter burst from the Sun formed planets[2], this paper provides a simple self-consistent model to explain many facts of the solar system and other planetary systems with theory of periodic bursts of stars and planets in their youth.

## 2. 7 evidences of periodic bursts of stars and planets in their youth

The first evidence of the theory of periodic bursts is found in a recently confirmed hot Jupiter V 830 Tau b orbiting a 2-Myr-old solar-mass T Tauri star at the distance of $a_1$=0.057(±0.001) AU with the orbital period of $P_1$=4.93(±0.05) days[3] and the velocity $v_1=2\pi a_1/P_1$=126 km/s. It originated from burst of the star after the birth of the star, with velocity a little larger than the Keplerian velocity above the surface of the star. The strong stellar wind pushed it away and caused it to accumulate a speed away from the star, while the medium in the stellar wind slowed down its revolution around the star. The stellar mass is $M_*=1.00\pm0.05M_\odot$ and the stellar radius is $a_0=R_*=2.0\pm0.2R_\odot$, so the Keplerian velocity above the surface of the star is $v_{\text{kep0}}=(GM_*/R_*)^{1/2}=(GM_\odot/2R_\odot)^{1/2}$=309 km/s, and the orbital period of a planet just born from the burst of the star in circular motion above the surface of the star is $P_0=2\pi R_*/v_{\text{kep0}}$=0.328 days. For a round celestial body there is $M=4\pi a_0^3 density/3$ and $P_0=2\pi a_0/v_{\text{kep0}}=2\pi a_0/(GM/a_0)^{1/2}=(3\pi/Gdensity)^{1/2}$, so the orbital period above its surface is determined by its density alone. So $a_1$, $P_1$ ,and $v_1$ are 6.1, 15.0, and 0.408 times of $a_0$, $P_0$, and $v_{\text{kep0}}$ respectively. Compared to the hypothesis of forming beyond a few au from the star and migrating inwards to its close-in orbit at 0.057 AU, the theory of periodic bursts is more convining. If the planet has a velocity a little greater than $v_{\text{kep}}$ at its birth, it will be in a moderately eccentric motion. The Keplerian velocity at the distance of $a_1$=0.057 AU is

$v_{\text{kep1}}=(GM_\ast/a_1)^{1/2}$=123 km/s, $v_1>v_{\text{kep1}}$, so the planet did have a velocity a little greater than the Keplerian velocity at its birth and it is in a moderately eccentric motion now. We do not know when the burst happened after the birth of the star. If we assume it happened just after the birth of the star, V 830 Tau b was 3.6 kilometers farther from V 830 Tau every year, from the original distance of 2×6.95500×$10^5$ km to the present distance of 0.057×1.4959787066×$10^8$ km because of the stellar wind. Classical T Tauri stars(CTTSs) lose great mass (about $10^{-7}M_\odot$)[2] every year because of stellar wind. Such strong stellar wind caused planet V 830 Tau b to leave the star and accumulate the velocity of 3.6 km/y away from the star. Later bursts of V 830 Tau will make more planets.

The second evidence is the similarity (Table 1) of the architectures of the planetary system of star Kepler-90 (KOI-351) and the solar system. Kepler-90 has five inner planets ranging from Earth to Mini-Neptune radii and two outer planets being gas giant[4]. The main differences between Kepler-90's system and the solar sytem are their ages and sizes. Kepler-90 has an estimated age of 2 Ga. The age of the Sun is more than 2 times of it. The distance from Kepler-90 to its fartherst planet is 1.01 AU and the distance from the Sun to the fartherst planet Nepture is 30.0690 AU. The difference of ages makes the difference of sizes. On average, the Earth was 33 meters farther from the Sun every year, from the original distance of 6.95500×$10^5$ km 4.556 Ga ago[5] to the present distance of 1.4959787066×$10^8$ km. For other planets in the Solar System, the velocity ranges from Mercury's 13 m/y to Neptune's 974 m/y. Further motions of Kepler-90's planets will make Kepler-90's planetary system reach the size of the Solar System in billions of years.

Table 1 Data of Kepler-90 and the Sun's planets

| Kepler-90's | $n$=0 | $n$=1 | $n$=2 | $n$=3 | $n$=4 | $n$=5 | $n$=6 | $n$=7 | |
|---|---|---|---|---|---|---|---|---|---|
| $a_n$[AU] | 0.005579 | 0.074 | 0.089 | 0.32 | 0.42 | 0.48 | 0.71 | 1.01 | |
| $a_n/a_{n-1}$ | | 13.26 | 1.2 | 3.6 | 1.3 | 1.1 | 1.5 | 1.4 | |
| $(a_n/a_{n-1})^3$ | | 2331 | 1.7 | 47 | 2.2 | 1.3 | 3.4 | 2.7 | |
| $P_n$[days] | 0.1393 | 7.008151 | 8.719375 | 59.73667 | 91.93913 | 124.9144 | 210.60697 | 331.60059 | |
| $P_n/P_{n-1}$ | | 50.31 | 1.244 | 6.851 | 1.539 | 1.359 | 1.686 | 1.574 | |
| $(P_n/P_{n-1})^2$ | | 2531 | 1.548 | 46.94 | 2.369 | 1.847 | 2.843 | 2.477 | |
| $(a_n/a_{n-1})^3/(P_n/P_{n-1})^2$ | | 0.9210 | 1.1 | 1.0 | 0.93 | 0.70 | 1.2 | 1.1 | |
| Sun's | $n$=0 | $n$=1 | $n$=2 | $n$=3 | $n$=4 | $n$=5 | $n$=6 | $n$=7 | $n$=8 |
| $a_n$[AU] | 0.00464913 | 0.38710 | 0.72333 | 1.00000 | 1.52366 | 5.20336 | 9.53707 | 19.1913 | 30.0690 |
| $a_n/a_{n-1}$ | | 83.263 | 1.8686 | 1.3825 | 1.52366 | 3.41504 | 1.83287 | 2.01228 | 1.56680 |
| $(a_n/a_{n-1})^3$ | | 577240 | 6.5245 | 2.6424 | 3.53724 | 39.8279 | 6.15737 | 8.14827 | 3.84628 |
| $P_n$[years] | 0.0003179 | 0.2408 | 0.6152 | 1.0000 | 1.8808 | 11.862 | 29.457 | 84.011 | 164.79 |
| $P_n/P_{n-1}$ | | 757.5 | 2.555 | 1.625 | 1.8808 | 6.3069 | 2.4833 | 2.8520 | 1.9615 |
| $(P_n/P_{n-1})^2$ | | 573806 | 6.528 | 2.641 | 3.5374 | 39.777 | 6.1668 | 8.1339 | 3.8475 |
| $(a_n/a_{n-1})^3/(P_n/P_{n-1})^2$ | | 1.00598 | 0.99946 | 0.99947 | 0.99995 | 1.0013 | 0.99847 | 1.0018 | 0.99968 |
| $e$ | | 0.205631 | 0.006773 | 0.016710 | 0.093412 | 0.048393 | 0.055723 | 0.044405 | 0.001121 |
| $RP_n$ | | 58.646 d. | 243.020 d. | 23.935 h. | 24.622 h. | 9.925 h. | 10.656 h. | 17.24 h. | 16.1 h. |
| $\omega_n(10^{-6}\,s^{-1})$ | | 1.2434 | 0.30006 | 72.920 | 70.885 | 175.6 | 163.79 | 101.2 | 108.3 |

In table 1, $a_1/a_0$ and $P_1/P_0$ are extremely large because the Sun and Kepler-90 stopped bursts billions years ago. They only burst in their youth when they are not stable. In the solar system, $a_5/a_4$ and $P_5/P_4$ are obviously larger than others because between the two regular bursts which bore

Jupiter and Mars there was an irregular burst comprising of many small bursts which bore Ceres ( perihelion: 2.7665 AU), 4 Vesta (perihelion: 2.57138 AU) and other asteroids in the Main Belt. In Kepler-90's system, $a_3/a_2$ and $P_3/P_2$ are obviously larger than others, so a planet or an asteroid belt must be there waiting for us to discover. For circular motions, there is $P_n=2\pi a_n/v_n=2\pi a_n/(GM/a_n)^{1/2}=2\pi a_n^{3/2}/(GM)^{1/2}$, so the value of $(a_n/a_{n-1})^3$ should be equal to the value of $(P_n/P_{n-1})^2$. If there is a little difference between these two values, it is caused by the eccentricity of the orbit, such as those of the Sun's. In the case of Kepler-90's, it is also caused by the inaccurate values of $a_n$ and $P_n$. Planets born from the bursts of stars always have velocities a little larger than the Keplerian velocity above the surface of the star and they move elliptically. Bode's law of the semimajor axes of planets and mean-motion resonance of orbital periods are two sides of one cause: the periodic bursts of stars. More than 20 years' research in isotopic systems has given us reliable estimates of the ages of Mars and Earth as 4.566 Ga and 4.556 Ga respectively[5], so the period of the bursts of the Sun can be estimated to be 10 Ma. The irregular burst comprising of many small bursts of the Sun lasted 20 Ma from 4.586 to 4.566 Ga ago and bore the parent bodies of meteorites. At present, the known earliest solids in the solar system are CAIs (calcium-aluminum-rich inclusions) in chondrites. Their age of 4.5673 Ga (or 4.5683 Ga)[5][6] is often used to define the start of the solar system. But it is wrong, because solids earlier than CAIs will be found when data and/or samples of dwarf planets outside Neptune or asteroids outside 4 Vesta are returned by spacecrafts in the future.

$RP_n$ and $\omega_n$ in the last two lines of Table 1 mean rotation period and angular speed of rotation of planet $n$. Mercury and Venus have similiar angular speed of rotation, about $1\times10^{-6}$ s$^{-1}$. Mercury is much smaller than Venus, so it cooled down and solidified earlier than Venus, thougt it was burst later. Earth and Mars have similiar angular speed of rotation, about $70\times10^{-6}$ s$^{-1}$. Mars is smaller than Earth and it was burst earlier, so it cooled down and solidified earlier than Earth. Jupiter and Saturn have similiar angular speed of rotation, about $180\times10^{-6}$ s$^{-1}$. Not listed in the table is Ceres with rotation period of 9.075 h and angular speed of rotation of $192.3\times10^{-6}$ s$^{-1}$, just like those of Jupiter and Saturn's. Uranus and Nepture have similiar angular speed of rotation, about $100\times10^{-6}$ s$^{-1}$. The jovian planets are much larger than the terrestrial planets, so they have not solidified until now. Ceres is the smallest, so it cooled down and solidified earliest. The angular speeds of rotation show the degree of violence of the bursts of the Sun, first high (for Nepture and Uranus), then highest (for Saturn, Jupiter, and Ceres), and then low (for Mars and Earth) ,and at last lowest (for Venus and Mercury).

The third evidence is the composition and low mean densities of the jovian planets which are similar to that of the Sun. Neptune, Uranus, Saturn and, Jupiter account for 99.5% of all the planetary mass in the solar system, so nuclear fusion has gone on since their birth from the bursts of the Sun 4.616, 4.606, 4.596, and 4.586 Ga ago and will go on into the future. Like the atmosphere of the Sun, their thick hydrogen-helium atmospheres have high internal temperatures and pressures to vaporize metal and rock, such as the *Galileo* probe in 1995. Except possibly for the lightest of them, Uranus, they radiate more energy than they receive. The internal heat source is too large to be explained by deday of radioactive elements[7]. Nuclear fusion is the only explanation. When bursting from the Sun, they were little suns. At present, they are still little suns in many ways.

The fourth evidence exists in the meteorites from asteroids. When bursting from the Sun, the asteroids were tiny suns with a surface temperature about 6400 K, the present temperature of the photosphere of the Sun. The small asteroids cooled down and solidified fast and without differentiation. Parts of them became chondrites and primitive achondrites found on the Earth. A few CAIs in chondrites have fragile, intricate textues like snowflakes, suggesting that they cooled down dirently from the vapors of the tiny suns to solids without ever being molten. Many chondrules appear to contain ‘chondrules within chondrules’[6], showing that they did not cool down dirently from the vapors of the tiny suns to solids. The large asteroids cooled down and solidified slowly and with differentiation, and became the differentiated meteorites found on the Earth, such as the iron meteorites from their cores, the stony-iron meteorites from their mantles, and the differentiated achondrites from their crusts or upper mantles. For example, the differentiated HED achondrites came from 4 Vesta, the second largest asteroid.

The fifth evidence exists in Mars. About 3.7 Ga ago, it was warm and there was widespread liquid water and valley networks[8]. It was at the present orbit of Earth or closer at that time. But then, slowly it moved to its present orbit and became a cold and dry planet. After bursting from the Sun, Mars and other terrestrial planets were all little suns and then experienced global differentiation in a long time of cooling down and solidification. SNCs, differentiated achondrites coming from Mars with young crystallization ages, proved the process of differentiation and later activities in Mars. The oldest achondrites from Mars, Allan Hills 84001 (ALH 84001, the only member of the subgroup Orthopyroxenite), has an age of 4.09 Ga, and is a fragment of the ancient Martian crust[9].

The sixth evidence exists in the ancient rocks from the crusts of the Earth and the Moon. These ancient rocks contained many radioactive matters, recording ‘the solar wind which was 10 million times stronger thant it is now’[10] in the time of planet formation. The first cause of such a strong solar wind is that the Earth and the Moon were much closer then to the Sun. Present distance from the Earth to the Sun is 215 times of the radius of the Sun, so the density of the solar wind at the surface of the Sun is 46225 times of that of the solar wind at the distance of 1 AU. It was later when the ancient rocks of the Earth and the Moon formed and then recorded the radioactive matters, but they were still closer to the Sun than it is now. And the density of the solar wind then at that distance from the Sun was still tens of thousands of times of that of the solar wind now at the distance of 1 AU, so the density alone made the solar wind tens of thousands of times stronger than it is now at the distance of 1 AU. The second cause is that the solar wind was stronger that it is now even in the same distance from the Sun. In the early time of the Sun, when it was a T Tauri star, it emitted matters of $10^{-7}$~$10^{-9}M_{\odot}$ per year[2]. Now ‘the Sun yearly loses ~$6.8\text{x}10^{19}$ g to the solar wind’[11], so it loses a little more than the mass of the Earth ($5.975\text{x}10^{24}$ kg) in 0.1 billion years. The solar wind then and later was stronger that it is now in the same distance from the Sun.

The seventh evidence exists in the regular satellites of planets. Planets in their youth were little suns. They were not stable and burst periodically, just like stars in their youth. Earth burst only once and bore the Moon 44.4 Ga ago[5]. Mars burst twice. The relations of orbital periods of their satellites are listed in Table 2, and those of the regular satellites of the jovian planets are listed in Table 3 and 4[12]. The jovian planets are much larger than Mars and Earth, and they burst more times than Mars and Earth. All regular satellites were formed from bursts of planets, with velocities and orbital periods a little greater than the Keplerian velocities (7.913 km/s for Earth as an example) above the surfaces of the planets and the corresponding orbital periods. The bursts of the planets are not as violent as those of the Sun, so regular satellites born from the bursts of a planet are in the state of synchronous rotation, keeping the same hemisphere toward the planet. The little planetal wind pushed the satellites away from the parent planet and caused them to accumulate a speed away from the planet, while the medium in the little planetal wind slowed down their revolution around the planet. On average, the Moon was 8.5 cm farther from the Earth every year, from the original distance of 6378 km 4.44 Ga ago to the present distance of $384.40\times10^3$ km. Currently, the Moon recedes 'from Earth at 3.79 cm/year'[13].

Table 2: Data of the Earth and Mars' satellites

| Earth's | $n$=0 | $n$=1, Moon | |
|---|---|---|---|
| $P_n$[days] | 0.05877 | 27.322 | |
| $P_n/P_{n-1}$ | | 464.9 | |
| Mar's | $n$=0 | $n$=1,Phobos | $n$=2,Deimos |
| $P_n$[days] | 0.0696 | 0.319 | 1.262 |
| $P_n/P_{n-1}$ | | 4.58 | 3.96 |

Table 3: Data of Jupiter and Neptune's satellites

| Jupiter's | $n$=0 | $n$=1,J15,J16 | $n$=2,J5 | $n$=3,J14 | $n$=4,J1 | $n$=5,J2 | $n$=6,J3 | $n$=7,J4 |
|---|---|---|---|---|---|---|---|---|
| $P_n$[days] | 0.1238 | 0.295,0.298 | 0.498 | 0.675 | 1.769 | 3.551 | 7.155 | 16.69 |
| $P_n/P_{n-1}$ | | 2.383,2.407 | 1.688,1.671 | 1.355 | 2.621 | 2.007 | 2.015 | 2.333 |
| Neptune's | $n$=0 | $n$=1,N3 | $n$=2,N4 | $n$=3,N5 | $n$=4,N6 | $n$=5,N7 | $n$=6,S/2004 N1 | $n$=7,N8 |
| $P_n$[days] | 0.109 | 0.294 | 0.311 | 0.335 | 0.429 | 0.555 | 0.950 | 1.122 |
| $P_n/P_{n-1}$ | | 2.70 | 1.06 | 1.08 | 1.28 | 1.29 | 1.71 | 1.18 |

Table 4: Data of Saturn and Uranus' satellites

| Saturn's | $n$=0 | $n$=1,S18 | $n$=2,S35 | $n$=3,S15 | $n$=4,S16 | $n$=5,S17 | $n$=6,S11,S10 | $n$=7,S53 | $n$=8,S1 |
|---|---|---|---|---|---|---|---|---|---|
| $P_n$[days] | 0.1751 | 0.575 | 0.597 | 0.602 | 0.613 | 0.629 | 0.694,0.70 | 0.808 | 0.942 |
| $P_n/P_{n-1}$ | | 3.28 | 1.04 | 1.01 | 1.02 | 1.03 | 1.10,1.11 | 1.16,1.15 | 1.17 |
| Uranus' | $n$=0 | $n$=1,U6 | $n$=2,U7 | $n$=3,U8 | $n$=4,U9 | $n$=5,U10 | $n$=6,U11 | $n$=7,U12 | $n$=8,U13 |
| $P_n$[days] | 0.1238 | 0.335 | 0.376 | 0.435 | 0.464 | 0.474 | 0.493 | 0.513 | 0.558 |
| $P_n/P_{n-1}$ | | 2.71 | 1.12 | 1.16 | 1.07 | 1.02 | 1.04 | 1.04 | 1.09 |
| $n$=9,S32 | $n$=10,S49 | $n$=11,S33 | $n$=12,S2 | $n$=13,S3,S13,S14 | $n$=14,S4,S12,S34 | $n$=15,S5 | $n$=16,S6 | $n$=17,S7 | $n$=18,S8 |
| 1.01 | 1.04 | 1.14 | 1.37 | 1.89,1.89,1.89 | 2.74, 2.74, 2.74 | 4.518 | 15.95 | 21.28 | 79.33 |
| 1.07 | 1.03 | 1.10 | 1.20 | 1.38 | 1.45 | 1.65 | 3.530 | 1.334 | 3.728 |
| $n$=9,U27 | $n$=10,U14 | $n$=11,U25 | $n$=12,U15 | $n$=13,U26 | $n$=14,U5 | $n$=15,U1 | $n$=16,U2 | $n$=17,U3 | $n$=18,U4 |
| 0.613 | 0.624 | 0.638 | 0.762 | 0.923 | 1.410 | 2.520 | 4.140 | 8.710 | 13.46 |
| 1.10 | 1.02 | 1.02 | 1.19 | 1.21 | 1.53 | 1.787 | 1.643 | 2.104 | 1.545 |

## 3. Conclusion

'No satisfactory explanation has ever been proposed'[14] for the Bode's law. This paper tried to give a systematic explanation for the Bode's Law and many facts of the solar system. The estimated moments of origin of planets from the bursts of the Sun in Table 1 may not be accurate, and the moments of origin of regular satellites from the bursts of the planets are not given, because we still lack samples from planets and satellites, except those from Mars, asteroids and the Moon. With the explorations of the solar system in the future, more samples will give us the exact ages of the planets and satellites, and the exact moments of origin of planets and satellites. Then the theory of periodical bursts of stars and planets will become mature from its birth at this moment.

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