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Solar and Lunar Eclipses in the Perspective of Shar'i and Astronomy

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ABSTRACT

The moon is a satellite that has its orbit and goes around the sun at the same time as the Earth. So that the special position between the Sun, Earth, and Moon can cause an eclipse. To complete this research, the author uses qualitative methods, namely descriptive methods. In this study, two approaches were carried out, namely: the Shari's approach which refers to Al-Qur'an and Hadith as the main legal foundation, and the Astronomy approach as a tool for studying the object of research in depth.

The results of the study can be concluded, solar eclipses are stated to occur when the position of the moon is located between the earth and the sun so that it closes part of the sun's light. In general, there are four types of solar eclipses, namely total solar eclipses, partial solar eclipses, ring solar eclipses, and hybrid solar eclipses. A lunar eclipse is a natural phenomenon that occurs when the sun, earth, and moon are on the same longitude when the moon is in opposition (i.e. at the time of the full moon) so that at that time the moon will pass through the earth's shadow. Lunar eclipses are divided into two types, namely penumbra lunar eclipses and umbra lunar eclipses. The calculation (Hisab) of the eclipse is carried out with the Ephemeris Hisab Rukyat system, which is used for the calculation of Qibla direction, prayer time, the beginning of the month Kamariah and the calculation of the eclipse.

I. Introduction

The solar system consists of diverse celestial objects, among them the Sun, eight planets (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune), and other elements in the solar system such as Comets, Meteors, Asteroids and Satellites. The moon is a satellite that has its orbit and circles the sun at the same time as the Earth. So that the special position between the Sun, Earth, and Moon can cause an eclipse. [1]

The term eclipse is familiar to us, eclipse is darkness that occurs when the shadow of an object moves in front of another object to block its light. Eclipse events occur every year, but the type of eclipse varies from region to region. For ordinary people, eclipses are common and sometimes often ignore the events of this step. But not infrequently also this eclipse phenomenon is said to be a sign of the coming disaster or mystical things according to the beliefs of ancient people. In the time of the Prophet SAW, the eclipse event was believed by the community as a sign of death or the birth of someone. But it was denied by the Prophet SAW in a hadith narrated by Al-Bukhari and Muslims which reads:

قال النبي صلى الله عليه وسلم "إن الشمس والقمر آيتان من آيات الله لا يخسفان لموت أحد ولا لحياته" متفق عليه

Means: "*The Prophet (peace be upon him) said: Verily the sun and the moon are two signs of the greatness of Allah, neither of which experience an eclipse because of a person's death nor because of his life*" *(Muttafaq 'alaihi)* (HR. Bukhari Muslim). [2]

Based on this hadith, it can be understood that the occurrence of eclipses is not caused by the death or life of a person, but a natural phenomenon that deserves wisdom and as one of the signs of the greatness of Allah SWT. Through the eclipse event, the Prophet SAW gave guidance if we see an eclipse then we are encouraged to perform the eclipse sunnah prayer.[3]

The term eclipse in English is *eclipse,* which is an astronomical phenomenon that occurs when a celestial body covers another celestial body because of the moon's revolution around the earth and the earth's revolution around the sun. In Islam, eclipses that have something to do with worship are twofold: solar eclipse and lunar eclipse. Solar eclipse in Arabic *al-kusuf* means "to cover", this describes the phenomenon of the moon covering the sun. Then a lunar eclipse in Arabic *al-khusuf* means "to enter", this describes the phenomenon where the moon enters the shadow of the earth. [4] To know more about lunar or solar eclipses their calculations will be explained in the next discussion.

II. Method

The method in this study uses qualitative methods, which are methods that are descriptive and focus on in-depth observation. Data collection techniques through *library*

research provide systematic, normative, and accurate explanations of the object that is the subject matter, using valid data.

This research approach includes two approaches, namely: the *shari'i* approach, where this approach is carried out through Islamic law using verses of the Qur'an and Hadith as the main legal foundation. And astronomical approach, this approach is used as a tool in studying in the depth of the object of research.

The source of data in this study is by the type of classification in library research, so the data used are data obtained through searching scientific books and other secondary reading sources. Where secondary data is data obtained by researchers from existing sources.

III. Results and Discussion

A. Solar eclipse (*al-kusuf*)

A solar eclipse is said to occur when the position of the moon lies between the earth and the sun so that it closes some or all of the sun's light.[5] Although the moon is smaller, the moon's shadow can block sunlight completely, this is because the moon which is an average distance of 384,400 (three hundred eighty-four thousand four hundred) kilometers from the earth is closer than the sun which has an average distance of 149,680,000 (one hundred forty-nine million six hundred eighty thousand) kilometers. Butar-Butar, Pengantar Ilmu Falak Teori, Praktik dan Fikih.

In astronomical studies, solar eclipses are somewhat more special than lunar eclipses. This is because, between these two celestial bodies, the sun has more objects of study. But in Islam, both get the same appreciation. Astronomically, a solar eclipse occurs when the umbra and/or penumbra of the moon falls to the Earth's surface. Because the moon is smaller than the sun, the shadow of the moon that falls on the surface of the earth only covers a narrow area.

In general, there are four types of solar eclipses, namely: (1) total solar eclipses, (2) partial solar eclipses, (3) ring solar eclipses, and (4) hybrid solar eclipses.**Alimuddin, "Solar Eclipse Astronomical Perspectives," Journal of Al-Daulah 3, no. 1 (2014): 72–79.** A total solar eclipse (*al-kusüf al-kully*) is when the sun's disk is completely covered by the moon's disk. A partial solar eclipse (*al-kusüf al-juz'iy*) is when the lunar disk at the time of the eclipse only partially covers the solar disk. A ring solar eclipse is when the lunar disk during an eclipse only covers part of the solar disk where the size of the lunar disk is smaller than the solar disk so that when the lunar disk is in front of the solar disk it is not entirely covered by the lunar disk. The part of the solar disk that is not covered by the lunar disk is around the lunar disk and looks like a luminous ring. Whereas hybrid solar eclipses are eclipses that shift between a total eclipse and a ring eclipse, these hybrid eclipses are relatively rare. For more details, you can see an illustration of the occurrence of a solar eclipse in the picture below.

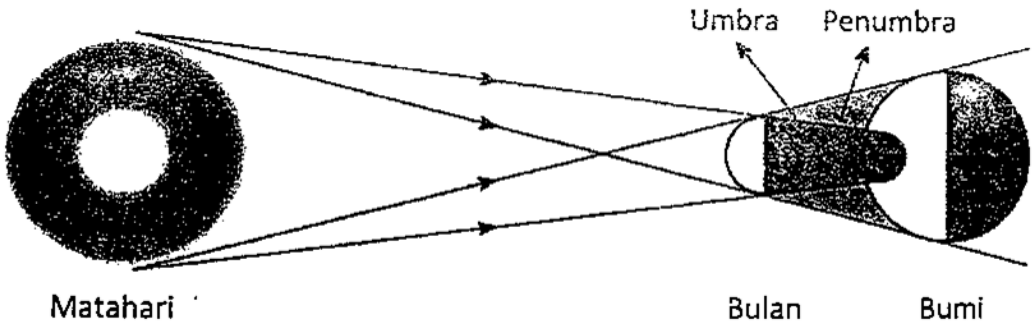

Figure 1. Solar Eclipse Illustration

B. Lunar eclipse (*al-khusuf*)

A lunar eclipse is a natural phenomenon that occurs when the sun, earth, and moon are on the same longitude when the moon is in opposition (i.e. at the time of the full moon) so that at that time the moon will pass through the earth's shadow. In this case, the shadow formed by the earth has two parts, namely the outermost shadow (*penumbra*) and the innermost shadow (*umbra*). Based on these two shadows, lunar eclipses are divided into two types, namely *penumbra lunar eclipses and* umbra *lunar eclipses*.

The phenomenon of *a penumbra eclipse* occurs when the moon passes through the earth's *penumbra* shadow which can only be seen when the lunar disk has entered more than half of the earth's *penumbra* shadow. While an *umbra lunar eclipse* occurs when the moon has passed through *the earth's umbra where at that time the entire lunar disk passes through the entire* umbra shadow*, the latter is called a total lunar eclipse, and if it passes through part of* the earth's umbra *it is called a partial lunar eclipse*.[2] Butar-Butar, Pengantar Ilmu Falak Teori, Praktik dan Fikih.

When a lunar eclipse occurs, the moon darkens as it enters the Earth's shadow, but there is still sunlight refracted by the atmosphere around the Earth. Clouds pollution, and dust can affect the color and brightness of the moon at the time of an eclipse and make it fade red. For more details, you can see an illustration of the occurrence of a lunar eclipse in the picture below.[7]

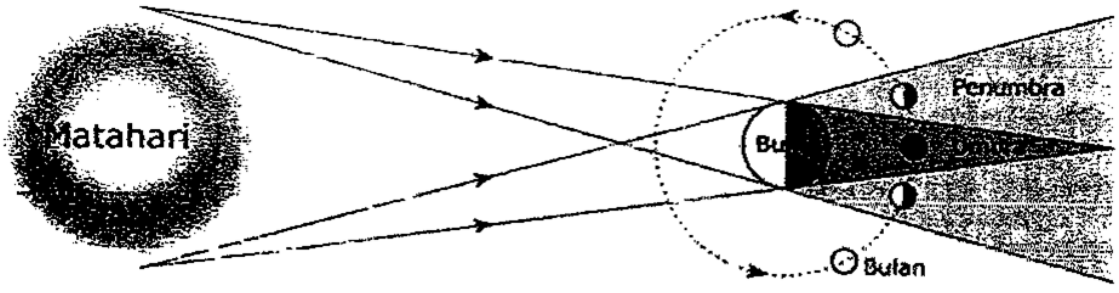

Figure 2. Ilustrasi Gerhana Bulan

C. Hisab Eclipse

The calculation (hisab) of eclipses can be done with the Ephemeris System Hisab Rukyat, more briefly called Ephemeris, is a set of astronomical data compiled by the Ministry of Religious Affairs of the Republic of Indonesia to be used as a reference in the problem of hisab and rukyat.[8] Ephemeris data is generally divided into two, namely

the sun and the moon. Both data are commonly used for calculating the direction of Qibla, prayer time, the beginning of the month of Kamariah, and the calculation of eclipses by Islamic mass organizations, falak institutions, and observers of hisab rukyat. The calculation of solar and lunar eclipses with the Hisab Rukyat Ephemeris System can be done with the following steps:

1. **Hisab Solar Eclipse**[9]
   1) Calculates the probability of a solar eclipse using data in *the majmu'ah*, *mabsuṭah* and lunar tables. These three data are added according to the month and year to be searched for the possibility of an eclipse. Furthermore, a solar eclipse may occur if the result of the sum is between the values of 00° to 20°, 159° to 190° and 348° to 360˚.
   2) Convert from the Hijri calendar used in calculating the probability of an eclipse to the Gregorian calendar used in the Ephemeris Hisab Rukyat data.
   3) Track the smallest *Fraction Illumination* (FIB) of Moon data in Hisab Rukyat Ephemeris according to the conversion date or around the conversion date.
   4) Looking at the certainty of a solar eclipse from the value of the *Moon's Apparent Latitude* at the time of the smallest *Fraction Illumination*, if the absolute value of *Apparent Latitude* > 1° 32' 02" then there is no solar eclipse, if the absolute value of *Apparent Latitude* < 1° 24' 10" then there must be a solar eclipse and if the absolute value of *Apparent Latitude* between 1° 32' 02" and 1° 24' 10" then there is a possibility of a solar eclipse.
   5) Calculate the time of the first ijtima', with the following steps:
      a. Calculate *the solar sabaq* (B1), by finding the difference between the solar *ecliptic longitude* (ELM) at the smallest FIB hour and the hour after it.
      b. Calculating the *Moon Sabaq* (B2), by calculating the difference between the *Apparent Longitude* of the Moon (ALB) at the smallest FIB hour and the hour after it.
      c. Calculates the distance between the Sun and Moon (MB), with the formula **MB = ELM – ALB**
      d. Calculating Sabaq *Mu'addal* Moon (SB), with formulas **SB = B2 - B1**
      e. Calculate ijtimak point (TI), with formula **TI = MB : SB**
      f. Calculating the time of the first ijtima' (Ijt1), **Ijt1 = jam FIB + TI**
   6) Prepare calculation data in the form of Semi diameter of the Moon (SDB), *Horizontal Parallaks* of the Moon (HPB), *Apparent Latitude* of the Moon or latitude of the Moon's ecliptic (LB), Semi diameter of the Sun (SDM), *True Obliquity* of the Sun (Obl) and *Equation of Time* (e).
   7) Calculates the middle time of the eclipse, with the following steps:
      a. Calculates *the Meredian Pass* (MP), with the formula **MP = 12 – e**
      b. Calculates the second ijtima (Ijt2), with the formula **Ijt2 = Ijt1 + (λ : 15)**
      c. Calculating ijtima distance (JI), **JI = [MP – Ijt2] x 15˚**
      d. Calculating *the first Āshir* (A1), with the rule that if **Ijt2 < MP**, then **A1 = ELM – JI**, jika **Ijt2 > MP**, then **A1 = ELM + JI**
      e. Counting *the first Mail Āshir* (MA1), **Sin MA1 = sin A1 x sin Obl**

f. Counting *the first Irtifa' Āshir* (IA1), **IA1 = 90 – [MA1 – φ]**
g. Calculating auxiliary angles (SP), **Sin SP = (sin SB x cos MA1) : (sin HPB x sin IA1)**
h. Counting *Sā'ah Bu'du al-Wasaṭ* (SBW), **SBW = sin JI : sin SP**
i. Calculates the middle of the eclipse (tgh) by the rule if **Ijt2 < MP**, maka **tgh = Ijt2 – SBW**, jika **Ijt2 < MP**, maka **tgh = Ijt2 + SBW**
j. Calculates the middle of an eclipse with the time area (TGH), TGH = tgh + (λD – λ) : 15.

8) Calculates the time of the beginning and end of a solar eclipse, with the following steps:
   a. Calculating eclipse distance (JG), **JG = [MP – tgh] x 15**
   b. Calculate the second *Āshir* (A2), with the rule if **tgh < MP**, then **A2 = ELM – JG**, then **tgh > MP**, then **A2 = ELM + JG**
   c. Counting *Mail Mail Āshir* Second (MA2), **Sin MA2 = sin A2 x sin Obl**
   d. Calculating *Irtifa' Second Āshir* (IA2), **IA2 = 90 – [MA2 – φ]**
   e. Counting *Ārḍu Iqlīm al-Rukyah* (AIR), **AIR = 90 – IA2** *Ārḍu Iqlīm al-Rukyah* Can be negative or positive, the determination is carried out with the following rules:
      1. If MA2 < 0 and φ > 0, then *Ārḍu Iqlīm al-Rukyah* is positive
      2. If MA2 > 0 and φ < 0 then *Ārḍu Iqlīm al-Rukyah* is negative
      3. If MA2 > 0 and φ > 0 then
         a) If [MA2] > [φ], then *Ārḍu Iqlīm al-Rukyah* is negative
         b) If [MA2] < [φ], then *Ārḍu Iqlīm al-Rukyah* is positive
      4. If MA2 < 0 and φ < 0 then
         a) If [MA2] > [φ], then *Ārḍu Iqlīm al-Rukyah* is worth positive
         b) If [MA2] < [φ], then *Ārḍu Iqlīm al-Rukyah* is worth negative
   f. Calculating *Ikhtilāf al-Arḍ* (IkA), **Sin IkA = [cos IA2 x sin 0° 51' 22"]** If AIR > 0, then *Ikhtilāf al-Arḍ* is negative while If AIR < 0, then *Ikhtilāf al-Arḍ* is positive.
   g. Counting *Ārḍu al-Qamar al-Mar'i* (LB'), **LB' = [LB + IkA]** If LB > 0, then *Ārḍu al-Qamar al-Mar'i* is positive, while if LB < 0, then *Ārḍu al-Qamar al-Mar'i* is negative. With reference to the value of *Ārḍu al-Qamar al-Mar'i*, the types of eclipses can be determined by looking at the values of the Semidiameter of the Sun and Semidiameter of the Moon using the following rules::
      1. If LB' < (HR + SDB), then:
         a) If SDB < (HR + LB'), then a partial eclipse occurs
         b) If SDB > (SDM + LB'), then a total eclipse occurs
         c) If HR < (SDB + LB'), then a ring eclipse occurs
      2. If LB' = 0 and HR = SDB, then there is a total eclipse of just a few seconds.
   h. Calculating *al-Jam'u* (J), **J = [SDB + SDM + [LB']]**
   i. Calculating *al-Bāqī* (B), **B = [SDB + SDM – [LB']]**
   j. Calculating *Daqāiq al-Kusūf* (DK), **DK = √ (J x B)**
   k. Calculating *Sabaq al-Mu'addal* (SM), **SM = SB - 0˚ 11' 48"**
   l. Calculating *Sa'ah al-Suqūṭ* (SS), **SS = DK : SM**

m. Calculates the beginning and end of an eclipse,

9) Calculating the Eclipse Width (LG), **LG = ((B : (SDM x 2)) x 100**
10) Calculating the eclipse width value in units of *usbu'* (LG'), **LG' = LG x 12**
11) Calculates total start time and total end, with steps:
    a. Counting *Sa'ah al-Mukśi* (SMk) **SMk = [12 – LG'] : 15**
    b. Calculates the beginning and end of the total phase, **Total beginning = TGH – SMk, Total end = TGH + SMk**.

2. Lunar Eclipse Calculation

1) Calculate the probability of a lunar eclipse using data in the eclipse table, by summing data from the year group table, year unit table and lunar eclipse table. Furthermore, a lunar eclipse may occur if the sum results range between 000˚ s/d 014˚, 165˚ s/d 194˚ dan 345˚ s/d 360˚.
2) Converting from the Hijri calendar to the Gregorian calendar is the date of the possible lunar eclipse and will only occur during the full moon, around the 15th of the Kamariah Month.
3) Find the largest *Fraction Illumination* (FIB) in the FIB column in the Hisab Rukyat Ephemeris according to the conversion date or around the conversion date.
4) Seeing the certainty of a lunar eclipse from the value of the *Moon's Apparent Latitude*, if the absolute price of the Moon's Latitude > 1° 05' 07" then there will be no lunar eclipse, if the absolute price of the Moon's Latitude < 1° 00' 24" then there will be a lunar eclipse.
5) Calculate the time of the first ijtima', with the following steps:
    a. Calculate *the solar sabaq* (B1), by finding the difference between the solar *ecliptic longitude* (ELM) at the largest FIB hour and the hour after it.
    b. Calculating the *Moon Sabaq* (B2), by calculating the difference between the *Apparent Longitude* of the Moon (ALB) at the largest FIB hour and the hour after it.
    c. Calculates the distance between the Sun and Moon (MB), with the formula **MB = ELM – (ALB – 180)**
    d. Calculating the Sabaq of the Moon *of Mu'addal* (SB), with the formula **SB = B2 - B1**
    e. Calculates the istiqbal point (TI), with formulas [**TI = MB : SB]**
    f. Calculates istiqbal time (IS), with formulas **[IS = Waktu FIB + TI – 00 : 01 : 49.29]**
6) Tracking data from ephemeris in the form of Semi Diameter Moon (SD), *ƒ Horizontal Parallaks* Moon (HP), *ƒ Apparent Latitude* of the Moon or latitude of the Moon's ecliptic (L), Semi Diameter of the Sun (SD), and Earth's Distance (JB) in the *ƒ True Geocentric Distance column*.
7) Calculates the Horizon Parallax (HP), with formulas:
   Sin Pho = sin 08.794" : JB
8) Calculates the distance of the month from the node (H), with formulas:
   Sin H = sin L*ƒ* : sin 5˚
9) Calculates the corrected maximum lunar latitude (U), with formulas:
   tan U = (tan L*ƒ* : sin H)

10) Calculates the minimum corrected lunar latitude (Z), with formulas:
Sin Z = (sin U x sin H)
11) Calculates the correction of the speed of the moon relative to the sun (K), with the formula: **K = cos L*f* x SB : cos U**
12) Calculates the magnitude of the semidiameter of the shadow of the Earth's core (D), with the formula: **D = (HP*f* + HP – SD) x 1,02**
13) Calculates the distance of the center of the Earth's core shadow to the center point of the moon when the lunar disk begins to come into contact with the shadow of the Earth's core (X), with the formula **X = D + SD*f***
14) Calculates the distance of the center of the shadow of the Earth's core to the center point of the moon when the entire lunar disk begins to enter the shadow of the Earth's core (Y), with the formula **(Y = D - SD*f*)**
15) Calculates the distance of the moon's center point when the lunar disk begins to come into contact with the shadow of the Earth's core (C), with the formula **Cos C = Cos X : Cos Z**
16) Calculates the time it takes for the moon to run from when the lunar disk comes into contact with the shadow of the Earth's core until when the center point of the moon aligns with the shadow of the Earth's core (T1), with the formula **T1 = C: K**. If Y is smaller than Z, there will be a partial lunar eclipse. Therefore, E and T2, do not need to be calculated.
17) Calculates the distance of the center point of the moon when it is in line with the shadow of the earth's core to the center point of the moon when the entire lunar disk enters the shadow of the earth's core (B), with the formula **(Cos E = Cos Y : Cos Z)**
18) Calculates the time it takes for the moon to run from the center point of the moon when it aligns with the shadow of the Earth's core to the center point of the moon when the entire lunar disk enters the shadow of the Earth's core (T2), with the formula **(T2 = E : K)**
19) First correction to the speed of the moon (Ta), with the formula:
Ta = Cos H : Sin K
20) The second correction to the speed of the moon (Tb), with the formula:
Tb = Sin L*f* : Sin K
21) Calculates eclipse time (T0), with formula **T0 = [Sin 0,05 x Ta x Tb]**
22) To calculate the time of the midpoint of an eclipse (Tgh) by: Note the Moon's latitude (LÄ) in the Moon's *Apparent Latitude column* at the largest FIB hour and in the next hour. If the absolute price of the Moon's Latitude is getting smaller, then **Tgh = Istiqbal + T0 - AT**. If the absolute price of the Moon's Latitude gets bigger then **Tgh = Istiqbal –T0 - AT**.
    a. AT is the correction of TT time to GMT
    b. To change to WIB, add 7 hours
    c. If the sum is more than 24, subtract by 24. Then the rest is the time of the midpoint of the eclipse.
23) Calculates eclipse start time, with formula:
Start Eclipse = Tgh – T1
24) Calculates the start time of a total eclipse, with formulas:

Total Start = Tgh – T2

25) Calculates the end time of a total eclipse, with formulas:
Total Completion = Tgh = T2
26) Calculates the eclipse end time, with the formula: **Eclipse Complete = Tgh + T1.** A lunar eclipse will be visible at night, so if the beginning of the eclipse is greater than sunrise, or the end of the eclipse is smaller than the sunset time of the sun somewhere then the lunar eclipse cannot be seen from that place.

If there is a partial lunar eclipse (Y < Z), then calculating the width of the eclipse (LG) or *magnitude*, namely the width of the lunar disk that enters the shadow of the earth's core can be done with the formula, **LG = ((D + SD – Z): 2 x SD) x 100%. *ff***. If the unit of measurement is desired with *ushbu*' (fingers), then the calculation of the width of this eclipse is multiplied by 12

IV. Conclusion

An eclipse is an astronomical phenomenon that occurs when a celestial body covers another celestial body due to the revolution of the moon around the earth and the revolution of the earth around the sun. In the Islamic context, eclipses related to worship are solar eclipses and lunar eclipses. A solar eclipse is a natural phenomenon that occurs when the position of the moon lies between the earth and the sun so that it closes some or all of the sun's light. In general, there are four types of solar eclipses, namely total solar eclipses, partial solar eclipses, ring solar eclipses, and hybrid solar eclipses. A lunar eclipse is a natural phenomenon that occurs when the sun, earth, and moon are on the same longitude when the moon is in opposition (i.e. at the time of the full moon) so that at that time the moon will pass through the earth's shadow. Lunar eclipses are divided into two types, namely *penumbra lunar eclipses and* umbra *lunar eclipses*.

Calculation (hisab) eclipses can be done with the Hisab Rukyat Ephemeris System, which is a set of astronomical data compiled by the Ministry of Religious Affairs of the Republic of Indonesia to be used as a reference in the problems of hisab and rukyat. Ephemeris data is generally divided into two, namely the sun and the moon. Both data are commonly used for the calculation of Qibla direction, prayer time, the beginning of the month of Kamariah, and eclipse calculations

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