PHASES OF THE MOON IN HIJRI DEATH (STUDY OF CALCULATION OF MOON PHASES WITH JEAN MEEUS' ALGORITHM)

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Abstract: The Hijri calendar is a dating system based on the circulation of the moon. In general, the Moon has four main phases, namely the New Moon phase, the First Quarter, the Full Moon, and the Last Quarter. Many methods are used for the calculation of the phases of the moon, one of which uses the calculation algorithm of Jean Meeus. The calculation of Jean Meeus' algorithm data was assisted using Microsoft Visual Basic software with calculations during the period of 2001 to 2100 AD, with output results in the form of dates, hours, and minutes of the occurrence of lunar phases in the month of Kamariah. From the calculation results, the average values of the synodic time of the phases of *the New Moon, First Quarter,* Full Moon, and *Last* Quarter are *29.53046138, 29.53027321, 29.53083066,* and 29.53090767, respectively. The results of Jean Meeus' analysis of lunar phase calculation data found that the length of the lunar synodic period from the New Moon phase to the next *New* Moon and the length of the synodic period of other lunar phases have differences, even though it is only a few seconds.
Keywords: Hijri Heritage; Phases of the Moon; Jean Meeus' Algorithm

1. INTRODUCTION

The Hijri calendar or what we commonly know as the Islamic calendar is a dating system that uses the circulation of the moon as a reference. The moon is the natural satellite of the earth. When observing the moon we notice that the shape of the moon seems to change every day and goes through a complete cycle in about a month. Changes in the shape or phase of the moon are caused by changes in the relative positions of the Moon, Sun and Earth. In general, the Moon is divided into four phases, namely the New Moon (*New Moon*), the first quarter (*First Quarter*), Full Moon (*Full Moon*), and Last quarter (*Last Quarter*) (Rizqi et al., 2021).

In the study of science will often intersect with this one object, the Moon. The month has an important influence on the Islamic calendar or the so-called Hijri calendar, where Muslims in setting the time of their worship based on this calendar system such as fasting, praying, Hajj and so on. Until now, many methods have been used to calculate when the phases of the moon occur in the lunar history, starting with the following. *Taqribi*, *haqiqi,* to contemporary. One of the contemporary methods included is Jean Meeus' algorithm (Manzil, 2018).

One of the most important things to know in the matter of determining the beginning of the lunar month is the characteristics of the moon and the phases of the moon. Hilal as the main object in determining the beginning of the moon is a rare celestial object (phenomenon) that not everyone can and can see. Conjunction or ijtima' as a condition for the entry of the new moon is a condition when the moon is between the sun and the earth, where the face of the moon becomes invisible from the earth (Jamaludin, 2018).

This article examines the phases of the moon in the lunar month with calculations by Jean Meeus' algorithm. The calculation of the phases of the moon was carried out using Microsoft Visual Basic 6.0 software, in the period 2001 to 2100 AD. From the results of these calculations will be analyzed related to the length of the moon phase of each phase

change, such *as from New Moon to New* Moon and from *Full Moon to* Full Moon, *as well as the* Quarter phase.

2. ANALYSIS OF STUDY FINDINGS

2.1 Terminology of the phases of the Moon

The moon is a celestial body that circulates around the Earth. It is the only natural satellite of the Earth with a diameter of 3,480 km. The Moon cannot emit light on its own, the source of the Moon's light that we see from Earth is the reflection of the Sun's rays.(Riza, 2020) The period of revolution of the moon in its orbital plane is calculated from the position of the new moon phase until it returns to the position of the new moon phase, which on average is taken in 29.53046138 days, or commonly called the period *synodis* (Musonnif, 2011). Changes in the shape of the Moon seen from Earth are always different, these are called phases of the Moon. The half of the Moon facing the Sun will be bright while the other side facing it will appear dark. However, these phases depend on the relative position of the Sun, Moon, and Earth. There are four main phases of the Moon, namely:

a) New Moon

New Moon or also known as *conjunction*, or in science call it ijtimak, is the position of the Sun and Moon at one astronomical longitude. The definition of ijtimak when connected with the new moon is an event when the Moon and Sun are located in the same longitude position. In essence, at this time there is still a part of the Moon facing the Earth, which gets the reflection of sunlight. But sometimes, because it is very thin, it cannot be seen from Earth, because the Moon is located close to the Sun (Azhari, 2005).

The new moon rises in the east almost at the same time as the Sun rises, and is in the middle of the sky also around noon and sets almost at the same time as the Sun sets. But when the Sun rises to almost set, we cannot see the crescent moon because the intensity of the Moon's light is inferior to the Sun's rays. The Moon will appear when the Sun is about to set with a crescent-like shape because the intensity of sunlight at that time weakens (Tono, 2007).

b) First *Quarter*

In this *First Quarter phase, the* crescent Moon begins to move from day to day, until the position of the crescent Moon is getting higher above the horizon. About seven days after the beginning of the month, the part of the Moon exposed to sunlight increases in size so that the Moon will appear from Earth in a semicircular shape. This phase is called the first quarter where the moon has entered a quarter of its circulation (Jamaludin, 2018). In this second phase, the rising and sinking of the Moon is slower than the Sun, estimated at 6 hours. It rises on the eastern horizon at noon, is in the middle of the sky around sunset, and sinks on the western horizon around midnight.

c) Full *Moon*

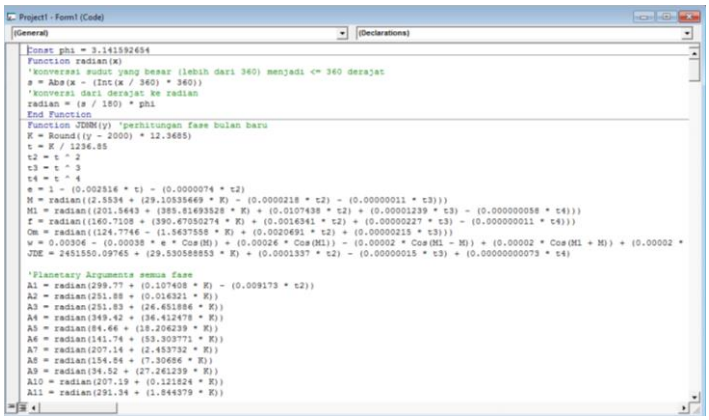
In the middle of the Moon around the 14th, 15th, and 16th of the moon, the Moon arrives at a position of opposition to the Sun. The part of the Moon that receives sunlight is almost entirely visible from Earth, and the Moon appears to be a full sphere. Conditions like this are called Full Moons or Full *Moons* (Muhyiddin, 2005). At full moon, the Moon is about 12 hours late from the Sun. The moon rises when the Sun sets, is in the middle of the sky at midnight and sets when the Sun rises. If at that time the position of the Moon is in line with the Earth and the Sun, then there will be a lunar eclipse, because the shadow of the Earth covers the Moon.

d) Last *Quarter*

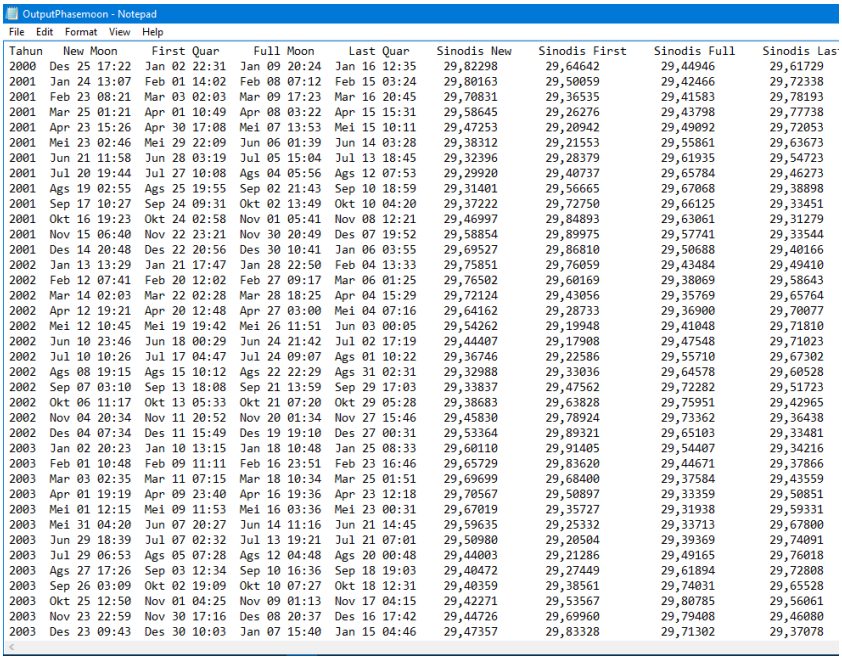
The Moon will continue to move and the shape of the Moon visible from Earth will get smaller. About 7 days after the Full Moon, the Moon will appear half as it did in the first quarter but in the opposite direction. This phase is called the *Last Quarter* which is the period of the moon that has passed about 22 1/8 days, which is similar to the first quarter (*First Quarter*) but with the opposite direction of crescent curve, which continues to move little by little towards the western horizon. In this phase, the Moon rises about 6 hours earlier than the Sun. This means, the Moon rises on the eastern horizon around midnight, right in the middle of the sky around sunrise and sets on the western horizon (Tono, 2007).

2.2 Analysis of the phases of the Moon Jean Meeus' algorithm

The calculation of the phases of the moon using the calculations of Jean Meeus' algorithm was carried out using the help of *Software* Microsoft Visual Basic 6.0, with calculations in the period 2001 to 2100. Previously, the author had made programming for the lunar phases of Jean Meeus' algorithm, with input year data and output results in the form of data on the occurrence of New Moon phases (*New Moon*), the first quarter (*First Quarter*), Full Moon (*Full Moon*), and Last quarter (*Last Quarter*) in units of hours and minutes of the process of the occurrence of the moon phase, also accompanied by the calculation of the length of the moon phase of each phase. In the calculation of the moon phase of Jean Meeus's algorithm, the results are expressed in Julian Day Ephemeris (JDE) with units of Dynamical Time (TD). Then, in order to be expressed in Universal Time (UT) or GMT, the time in TD needs to be corrected with Delta T.(Jean, 1998) which in this case the author uses Delta T calculations on NASA's website https://eclipse.gsfc.nasa.gov/SEhelp/deltatpoly2004.



Picture. 1 Display of moon phase programming algorithm Jean Meeus in *Software* Microsoft Visual Basic 6.0



OutputPhasemoon - Notepad

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Tahun	New Moon	First Quar	Full Moon	Last Quar	Sinodis New	Sinodis First	Sinodis Full	Sinodis Las
2000	Des 25 17:22	Jan 02 22:31	Jan 09 20:24	Jan 16 12:35	29,82298	29,64642	29,44946	29,61729
2001	Jan 24 13:07	Feb 01 14:02	Feb 08 07:12	Feb 15 03:24	29,80163	29,50059	29,42466	29,72338
2001	Feb 23 08:21	Mar 03 02:03	Mar 09 17:23	Mar 16 20:45	29,70831	29,36535	29,41583	29,78193
2001	Mar 25 01:21	Apr 01 10:49	Apr 08 03:22	Apr 15 15:31	29,58645	29,26276	29,43798	29,77738
2001	Apr 23 15:26	Apr 30 17:08	Mei 07 13:53	Mei 15 10:11	29,47253	29,20942	29,49092	29,72053
2001	Mei 23 02:46	Mei 29 22:09	Jun 06 01:39	Jun 14 03:28	29,38312	29,21553	29,55861	29,63673
2001	Jun 21 11:58	Jun 28 03:19	Jul 05 15:04	Jul 13 18:45	29,32396	29,28379	29,61935	29,54723
2001	Jul 20 19:44	Jul 27 10:08	Ags 04 05:56	Ags 12 07:53	29,29920	29,40737	29,65784	29,46273
2001	Ags 19 02:55	Ags 25 19:55	Sep 02 21:43	Sep 10 18:59	29,31401	29,56665	29,67068	29,38898
2001	Sep 17 10:27	Sep 24 09:31	Okt 02 13:49	Okt 10 04:20	29,37222	29,72750	29,66125	29,33451
2001	Okt 16 19:23	Okt 24 02:58	Nov 01 05:41	Nov 08 12:21	29,46997	29,84893	29,63061	29,31279
2001	Nov 15 06:40	Nov 22 23:21	Nov 30 20:49	Des 07 19:52	29,58854	29,89975	29,57741	29,33544
2001	Des 14 20:48	Des 22 20:56	Des 30 10:41	Jan 06 03:55	29,69527	29,86810	29,50688	29,40166
2002	Jan 13 13:29	Jan 21 17:47	Jan 28 22:50	Feb 04 13:33	29,75851	29,76059	29,43484	29,49410
2002	Feb 12 07:41	Feb 20 12:02	Feb 27 09:17	Mar 06 01:25	29,76502	29,60169	29,38069	29,58643
2002	Mar 14 02:03	Mar 22 02:28	Mar 28 18:25	Apr 04 15:29	29,72124	29,43056	29,35769	29,65764
2002	Apr 12 19:21	Apr 20 12:48	Apr 27 03:00	Mei 04 07:16	29,64162	29,28733	29,36900	29,70077
2002	Mei 12 10:45	Mei 19 19:42	Mei 26 11:51	Jun 03 00:05	29,54262	29,19948	29,41048	29,71810
2002	Jun 10 23:46	Jun 18 00:29	Jun 24 21:42	Jul 02 17:19	29,44407	29,17908	29,47548	29,71023
2002	Jul 10 10:26	Jul 17 04:47	Jul 24 09:07	Ags 01 10:22	29,36746	29,22586	29,55710	29,67302
2002	Ags 08 19:15	Ags 15 10:12	Ags 22 22:29	Ags 31 02:31	29,32988	29,33036	29,64578	29,60528
2002	Sep 07 03:10	Sep 13 18:08	Sep 21 13:59	Sep 29 17:03	29,33837	29,47562	29,72282	29,51723
2002	Okt 06 11:17	Okt 13 05:33	Okt 21 07:20	Okt 29 05:28	29,38683	29,63828	29,75951	29,42965
2002	Nov 04 20:34	Nov 11 20:52	Nov 20 01:34	Nov 27 15:46	29,45830	29,78924	29,73362	29,36438
2002	Des 04 07:34	Des 11 15:49	Des 19 19:10	Des 27 00:31	29,53364	29,89321	29,65103	29,33481
2003	Jan 02 20:23	Jan 10 13:15	Jan 18 10:48	Jan 25 08:33	29,60110	29,91405	29,54407	29,34216
2003	Feb 01 10:48	Feb 09 11:11	Feb 16 23:51	Feb 23 16:46	29,65729	29,83620	29,44671	29,37866
2003	Mar 03 02:35	Mar 11 07:15	Mar 18 10:34	Mar 25 01:51	29,69699	29,68400	29,37584	29,43559
2003	Apr 01 19:19	Apr 09 23:40	Apr 16 19:36	Apr 23 12:18	29,70567	29,50897	29,33359	29,50851
2003	Mei 01 12:15	Mei 09 11:53	Mei 16 03:36	Mei 23 00:31	29,67019	29,35727	29,31938	29,59331
2003	Mei 31 04:20	Jun 07 20:27	Jun 14 11:16	Jun 21 14:45	29,59635	29,25332	29,33713	29,67800
2003	Jun 29 18:39	Jul 07 02:32	Jul 13 19:21	Jul 21 07:01	29,50980	29,20504	29,39369	29,74091
2003	Jul 29 06:53	Ags 05 07:28	Ags 12 04:48	Ags 20 00:48	29,44003	29,21286	29,49165	29,76018
2003	Ags 27 17:26	Sep 03 12:34	Sep 10 16:36	Sep 18 19:03	29,40472	29,27449	29,61894	29,72808
2003	Sep 26 03:09	Okt 02 19:09	Okt 10 07:27	Okt 18 12:31	29,40359	29,38561	29,74031	29,65528
2003	Okt 25 12:50	Nov 01 04:25	Nov 09 01:13	Nov 17 04:15	29,42271	29,53567	29,80785	29,56061
2003	Nov 23 22:59	Nov 30 17:16	Des 08 20:37	Des 16 17:42	29,44726	29,69960	29,79408	29,46080
2003	Des 23 09:43	Des 30 10:03	Jan 07 15:40	Jan 15 04:46	29,47357	29,83328	29,71302	29,37078

Picture. 2 The output result of the calculation of the moon phase of Jean Meeus' algorithm uses *Software* Visual Basic Microfot 6.0

From the data from the calculation of the lunar phase of Jean Meeus's algorithm obtained the average value for the length of time of the phases of the Moon in a period of 1099 years, namely from 2001 to 2100. The average phase of *the New Moon to the next* New Moon is 29.53046138 or 29 days 12 hours 43 minutes 52 seconds. While the average phase of the Full *Moon (Full Moon)* to the next Full Moon (Full *Moon*) is 29.53027321 or 29 days 12 hours 43 minutes 36 seconds. The average phase of the first quarter to *the* next quarter is 29.53083066 or 29 days 12 hours 44 minutes 24 seconds. While the average for the final quarter phase (Last Quarter) *to the next quarter (*Last Quarter*) is 29.53090767 or 29 days 12 hours 44 minutes 30 seconds.*

3. CONCLUSION

The results of data analysis of lunar phase calculations with Jean Meeus' algorithm show that the length of the lunar synodic period from the *New* Moon phase to the next New Moon with the length of the synodic period of other lunar phases has differences, even if it is only a few seconds. The time interval from New Moon to the next *New Moon* which ranges from 29 days 5.5 hours to 29 days 20 hours makes the age of the moon in the Hijri calendar varies, amounting to *29 days, 30 days, alternating 29 and 30 days, two consecutive months of 29 days and two consecutive months of 30 days.*

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