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Astronomy

On the Accuracy of the Contemporary Calendar

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ABSTRACT. Taking into account the tidal friction, a reform of the calendar is proposed. The useful period of such calendar can be essentially prolonged and the error will be less than 0.5 days within 10000 years.

Key words: tidal friction, calendar, reform.

1. Introduction

The contemporary calendar was founded by Julius Caesar in Rome in 46 B.C. In this calendar every fourth year (leap-year) contains 366 days but the other years – 365. So the duration of middle Julian year is 365.25 days.

Today the Julian calendar named "Old Style", is used by the Orthodox church.

Because the length of the tropical year is shorter by 0.008 days than the Julian year, a considerable error had accumulated over centuries, which was corrected by Pope Gregory XIII in 1582.

For this purpose he deleted 11 days from the calendar and introduced a new rule of calculation of leap-years. According to this rule, during every four centuries three leap-years must be taken away from the last three centuries, the number of which can not be divided by 4 (i.e. 1700, 1800, 1900, 2100 etc). The duration of the middle Gregorian year is 365.2425 days.

The Gregorian calendar, named "New Style", is used today by the majority of countries.

2. The effect of secular lengthening of a day by tidal friction

It is reckoned that the Gregorian calendar accumulates the systematic error one day per 3300 years.

However, such calculation does not take into account that the period of the Earth's rotation on its polar axis has not been constant throughout Earth's history and that there has been a deceleration attributable to the dissipation of rotational energy by tidal forces.

Accordingly, the investigations of palaeobotanists show that throughout geological time the number of days in the tropical year or in the month was not constant [1-6]: in different geological epochs the year contained 370, 390 and even 424 days.

The measurement of lunar acceleration and acceleration of Earth's rotation by satellite observations [7] is in good agreement with results received by other methods.

The list of such investigations is given in [8].

Taking into account the effect of tidal friction the duration of tropical year is equal to:

$$P = 365.24219879 - 0.00000614\, t, \qquad (1)$$

where t is Julian centuries passed after the end of 19th century or, if T is counted from the beginning of contemporary chronology (A.D.):

$$P = 365.24231545 - 0.00000614\, T. \qquad (2)$$

By integration of (2) we receive that the number of days after beginning of our chronology till the end of T century is equal to

$$N = 36524.231545\ T - 0.000307\ T^2. \qquad (3)$$

According to (3) New Style makes an error of 1 day after 2500 years, instead of 3300 (as it is reckoned now) and this interval will be reduced in future.

3. My project of reducing the systematic error in the calendar

Now, I propose the following method of prolonging the usful period of a calendar.

As mentioned above, in the New Style there are excepted three leap-years during four centuries, the number of which cannot be divided by 4.

According to the proposed rule, during every five centuries in future there must be taken off four leap-years from the last three centuries, the number of which cannot be divided by 5 (i.e. 2100, 2200, 2300, 2400, 2600 etc). In such case the duration of the middle year becomes 365.242 days.

The tropical year will acquire such length in the 52nd century. Before this epoch the proposed calendar must forestall the tropical year, but later it will become slower and compensate for the accumulated error. As a result the error of such calendar could not exceed half a day even for very long time.

The results of this idea are illustrated in the Table in which for the end of each millennium the difference (in days) between the New and Old Styles (ΔT_G), of the proposed calendar with Old Style (ΔT_C) and the error of the Old Style (ΔT_J) are given.

Table.

Residuals between different calendars and Old Style

Year	ΔT_G	ΔT_C	ΔT_J
2000	13	13	12.99
3000	21	21	20.83
4000	28	29	28.73
5000	36	37	36.69
6000	43	45	44.71
7000	51	53	52.80
8000	58	61	60.94
9000	66	69	69.15
10000	73	77	77.42

Obviously, the data of the last two columns of the Table differ by less than 0.5 days within 10000 years.

Therefore, beginning with the 21st century if we do not consider as leap-years the last years of centuries the numbers of which can be divided by 4 (2000, 2400, 2800 etc), but only those which can be divided by 5 (2000, 2500, 3000 etc), the useful period of such calendar can be essentially prolonged, relieving the life of our remote descendants.

ასტრონომია

თანამედროვე კალენდრის სიზუსტის შესახებ

რ. კილაძე

აკადემიის წევრი, ე. ხარაძის საქართველოს ეროვნული ასტროფიზიკური ობსერვატორია

მოქცევითი ხახუნის მოვლენის გათვალისწინებით ნაშრომში შემოტანილია კალენდრის რეფორმის წინადადება. კალენდრის ამ ვარიანტს საგრძნობლად გახანგრძლივებული აქვს ვარგისობის ვადა: მისი ცდომილება 10000 წლის განმავლობაში არ აჭარბებს 0.5 დღე-ღამეს.

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