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C/2012 S1 (ISON): EARLY OBSERVATIONS AT MT. LEMMON SURVEY

Comet C/2012 S1 (ISON) promises to be a great comet in November-December 2013, near its perihelion. At the moment of its discovery it was already quite bright, with a well-defined coma. The CCD-images of the comet, taken by Mt. Lemmon sky survey nine months before it was officially discovered, have been thoroughly examined. At that time the object was located at a distance of 8.67 A.U. from the Sun. The examination of the images revealed well-marked comet activity: the share of the coma into the integrated brightness of the comet exceeded hundredfold the share of the nucleus. The coma of comet was no more than 60 000 km in diameter.

Key words: comet C/2012 S1 (ISON), Mt. Lemmon, comet activity, great comet

INTRODUCTION

Comet C/2012 S1 (ISON), discovered on September 21, 2012 by V. Nevsky and A. Novichonok [4], belongs to the rare type of sungrazers, or circumsolar comets. It was passing its perihelion point on November 28, 2013 at a distance of 0.012 A.U. from the Sun [11]. Based on the orbital elements of C/2012 S1 [12] we can make a logical conclusion that the ISON is Oort-cloud comet that enters the inner part of the Solar system for the first time, since $1/a_{orig}$ of its orbit no larger than 0.00005 (equals to near 0.00000852 [10], [12].

At the time of its discovery the total brightness of the comet was brighter than 18^m, it displayed a compact but well-defined coma, being located at a distance of 6.29 A.U. from the Sun [4].

But it turned out that two sky survey telescopes – Mt. Lemmon (Arizona, U.S.A.) and PANSTARRS (the Hawaiian Islands, U.S.A.) – had already detected this object nine and eight months respectively before it was discovered, failing to recognize it as a new comet [11].

The present work analyses the images of C/2012 S1, taken at Mt. Lemmon observatory nine months before the official discovery. The main question that was raised in the work is – whether one can speak for sure of any activity at such a considerable heliocentric distance (8.67 A.U.).

Thanks to the emergence of automatic sky surveys (the most productive of which currently being Catalina, Mt. Lemmon, PANSTARRS, all of them – in the USA), the observation and discoveries of comets at a considerable distance from the Sun are becoming more and more frequent. Some specific research and exploration are also being done in this direction [eg., 7]. Despite that, such observation is still sporadic, only a few comets (mainly short-period ones) at a considerable distance from the Sun have been studied and characterized in detail. Thus, this work aims to expand our knowledge about the activity of the comet, that has come from Oort cloud at a considerable distance from the Sun.

METHODS

The images that are being analyzed were obtained by R. Kowalsky on December 28, 2011 with a 1.5-m f/2 telescope of Mt. Lemmon observatory (the University of Arizona) with a CCD sensor SI 600–386 (maximum sensitivity while shooting without filters in the red region). Altogether there were four photographs with a 30-s exposure, without filters (the limiting magnitude of images reaches approximately 20.7CR, the scale is 0.96»/px). Images were calibrated (darks and flat fields). The aperture photometry of the comet was done in the Astrometrica software tool, comparison star catalogue – NOMAD (R-stars).

The effective diameter of the nucleus was calculated according to the Jewitt formula [6] in Ferrin simplification [1] for images made in the R-filter:

$$Log\left[\frac{P_r \times D_{eff}^{\,2}}{4}\right] = 5.510 - 0.4R_N(1,1,0),$$

P_r – the geometrical albedo of the nucleus in the R-light. D_{eff} – the effective diameter of the nucleus [1], km. R_N (1,1,0) – the absolute brightness of the nucleus in R-light (at a distance of 1 A.U. from the Sun and Earth and the phase angle of 0 degrees).

The value of the albedo was assumed equal to 4 % [2]. In the process of determining the absolute brightness of the nucleus the phase coefficient was assumed equal to 0.04 [7].

This formula should be applied with reserve, because it is only possible to determine the nucleus effective diameter of a comet with certainty, when the comet is absolutely inactive. And in this case one must have in mind that even when the comet in its appearance looks like a star (its FWHM approximately amounts to that of a star in the same images), it can have a coma, which remains undetectable due to the low resolution of the equipment used. In this investigation a reversed reduction is done: since we know roughly the nucleus diameter of a comet, our objective is to independently determine the effective diameter based on our own observation and, having compared it with the known diameter, to draw a conclusion about the presence or absence of any activity at a considerable distance from the Sun.

RESULTS AND DISCUSSION

The FWHM of the comet in the sum of three photographs equaled to 3.2", which was not statistically different from the value for stars of the same brightness as the comet (3.1" on average). Thus, based on these photographs, one cannot speak of any stated diffuseness of the object (Fig.).

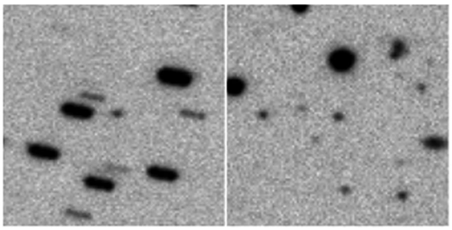

Fig. The sum of 3 CCD-images with a 30-sec exposure each in the direction of the comet motion (left) and the stars (right)

The comet brightness was 18.9 CR. Based on this brightness and with the assumption that it was fully provided by the input of the nucleus, the estimated absolute brightness and the effective diameter of the comet nucleus were determined – 9.5CR and 72 km respectively. There are some error in these calculations, due to the fact that the photographs were taken without filters. However the primary investigation of the data obtained recently by the Hubble space telescope showed that the diameter of the nucleus of C/2012 S1 totaled 5–7 km [5], which corresponds to the absolute brightness of around 15–16 R. Therefore it becomes obvious, that even at such a great distance from the Sun the comet activity of C/2012 S1 was well-marked: the input of the coma into the integrated brightness of the object was one hundred times bigger that the input of the nucleus.

Apparently, the comet diffuseness cannot be seen due to the mediocre seeing. Nevertheless, we estimated the maximum possible physical diameter of the coma – 60 000 km. If it were bigger, the outer diffuseness of the comet could have been recorded in the CCD-images of Mt. Lemmon survey. The images of PANSTARRS observatory taken on January 28, 2012 [9] represent a high potential for further detalization of ours result.

Such well-marked activity at such great distances from the Sun is not a rare case for those comets that approach the Sun for the first time. That was the case, for instance, with comet C/2011 L4 (PANSTARRS), which on the day of its discovery in June, 6, 2011 was at 7.9 A.U. away from the Sun, but, however, displayed demonstrable comet activity [3].

CONCLUSION

Based upon the analysis of the CCD-images of comet C/2012 S1 (ISON), made 9 months before its official discovery at Mt. Lemmon observatory, the following conclusions were made:

1. Even at a distance of 8.67 A.U. the activity of C/2012 S1 (ISON) was well-defined, which confirms the findings that the object entered the inner part of the Solar system for the first time.

2. The physical dimension of the coma of C/2012 S1 at a distance of 8.67 A.U. from the Sun was no more than 60 000 km across.

For further study of the details of the comet activity and motion at a long distance from the Sun it is recommended to study the photographs of PANSTARRS observatory made on January 28, 2012, exactly one month later than the ones we have studied.

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