# STARS RESOURCES

*Teacher notes*

## *Tracking sunspots*

### ACTIVITY

Students will:

- Track the motion of sunspots across the surface of the Sun
- Use the measurements of sunspot motion to calculate the rotation of the Sun
- Apply simple harmonic motion equations to their measurements
- Recognise the importance of simple harmonic motion to systems involving non-constant acceleration

### BACKGROUND INFORMATION

Sunspots are patches of intense magnetic fields on the surface of the Sun. The fields are so strong that the convection currents bringing up hot material are inhibited. Therefore, these patches are cooler than the surrounding areas, and appear black.

This activity uses data from NASA's SOHO (Solar and Heliospheric Observatory) taken in January 2014 during a solar maximum.

Students will need to be familiar with simple harmonic motion, and its application to non-constant acceleration systems.

Watch this video or show it to the students, 'Comparing Simple Harmonic Motion (SHM) to Circular Motion – Demonstration', Flipping Physics (2:27 mins), https://www.youtube.com/watch?v=JSBw-JyFgZk (3 June 2018)

The Sun is rotating on its axis. Different layers of the Sun rotate at different speeds, and different sections of each layer rotate at different speeds. This activity will measure the photosphere layer's rotational speed around the equator.

### CURRICULUM LINKS

AUSTRALIAN CURRICULUM - YEAR 12 Specialist Mathematics

Consider and solve problems involving motion in a straight line with both constant and non-constant acceleration, including simple harmonic motion and the use of expressions for acceleration. (ACMSM136)

## EQUIPMENT

You will need the following to complete this activity:

- Print-outs of the images of the Sun from SOHO (supplied)
- Ruler with millimetres marked
- Pen/paper
- Excel or equivalent graphic software

## MAKING MEASUREMENTS

1. Use the ruler to measure the displacement (x) of the big sunspot from the central axis of the Sun. As an estimate, use the centre of the sunspot each time and try to be as consistent as possible. Measurements can be taken in millimetres.

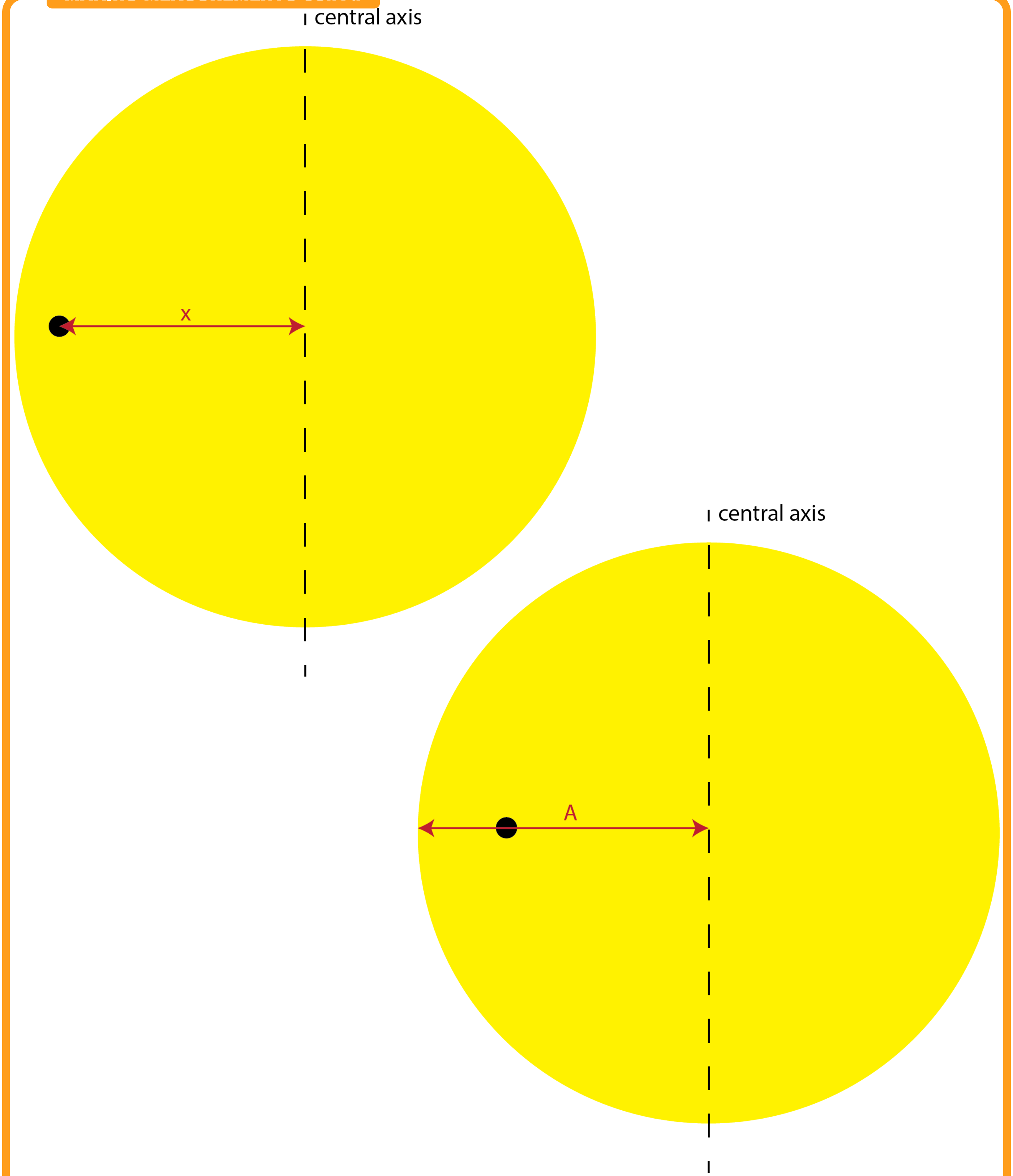
2. Also measure maximum displacement (A). This measurement only needs to be done once to obtain a value for A . Find the latitude of the sunspot, and measure the distance from the central axis to the outside edge of the Sun's image.

3. Record these for each image.

4. Also record time (t) in hours. The first measurement will be at zero hours. Students will need to calculate the time difference between each image using the time stamp information in the filenames.

NOTE: Altogether, there will be a value for x, A and t for each image.

## MAKING MEASUREMENTS cont'd



## CALCULATION

The equation for simple harmonic motion is:

$$x = A\sin(\omega t + \varphi)$$

*x* is displacement

*t* is time in hours

*A* is maximum displacement

ω is angular frequency (i.e. angular displacement per unit time, e.g. in rotation):

$$\omega = 2\pi f$$

φ is phase constant

The equation for frequency is:

$$f = \frac{1}{T}$$

*T* is period, the time for one rotation, also known as the orbital period

Now replace *f* in angular frequency equation:

$$\omega = \frac{2\pi}{T}$$

T is what we're after!

Now insert ω into the equation for simple harmonic motion:

$$x = A\sin\left(\left(\frac{2\pi}{T}\right)t + \varphi\right)$$

$$\sin^{-1}\left(\frac{x}{A}\right) = \left(\frac{2\pi}{T}\right)t + \varphi$$

## RESULTS

After the above mathematical manipulation, we have created an equation in the form of $y = mx + c$.

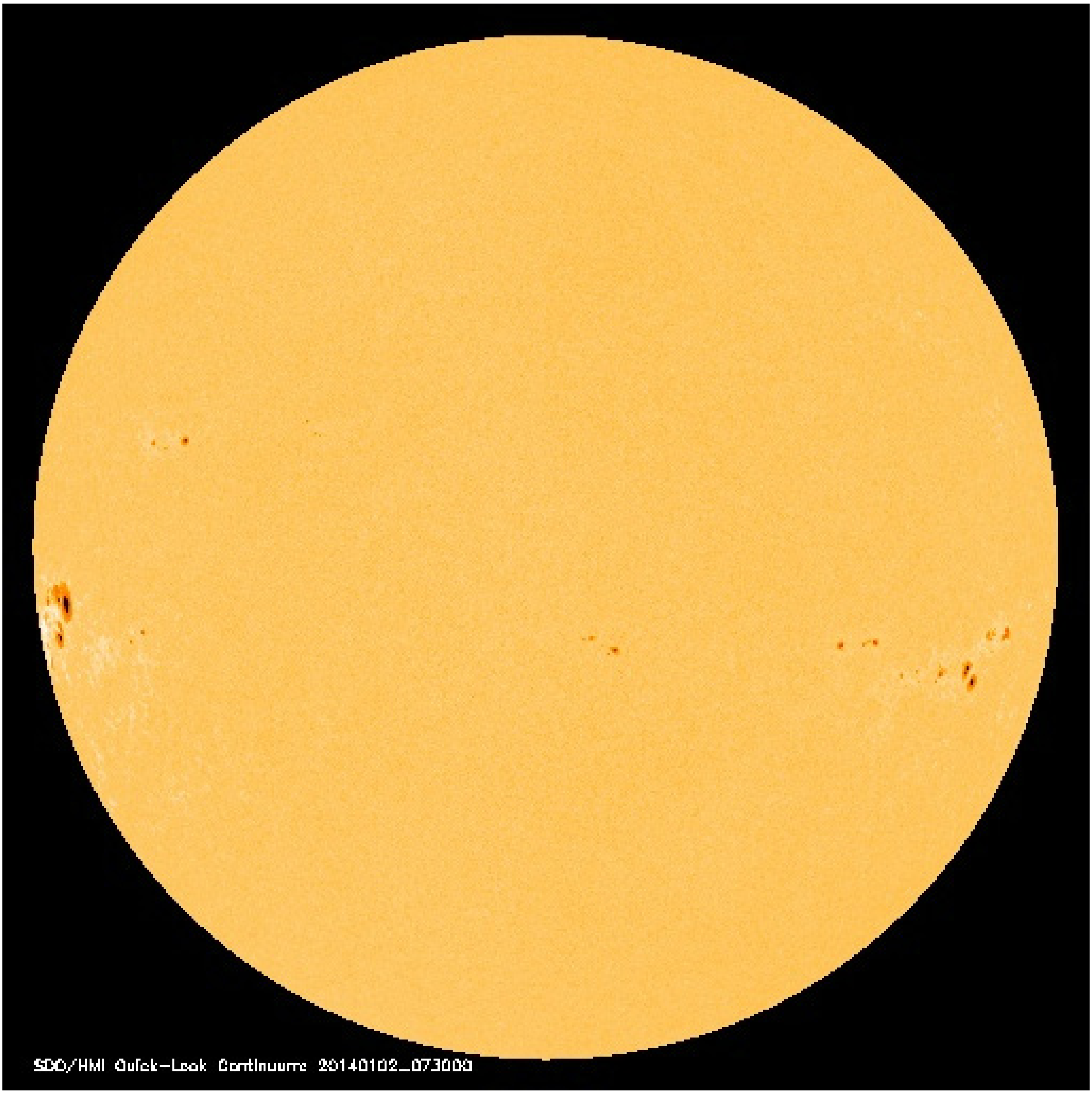
Therefore, with your values for *x* and *A*, calculate $\sin^{-1}\left(\frac{x}{A}\right)$ for each image, and plot that against *t*.

Fit a line of best fit to the data.

The gradient of this line is the rotational frequency ($\omega$) of the Sun in units of radians per hour.

Insert into $T = \frac{2\pi}{\omega}$ to give a value in hours. Convert to days.

Your result should be in the vicinity of 26 days.

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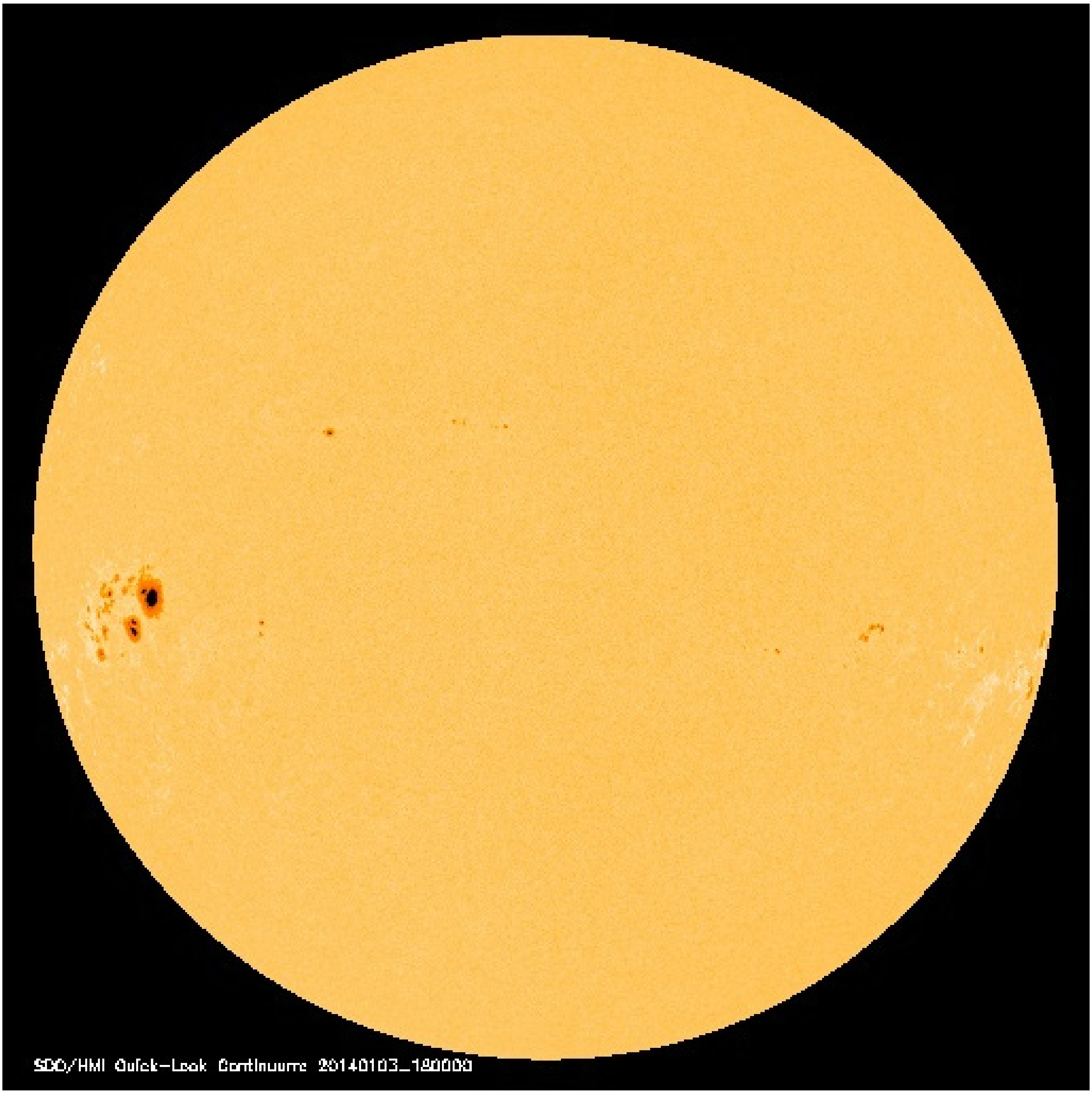


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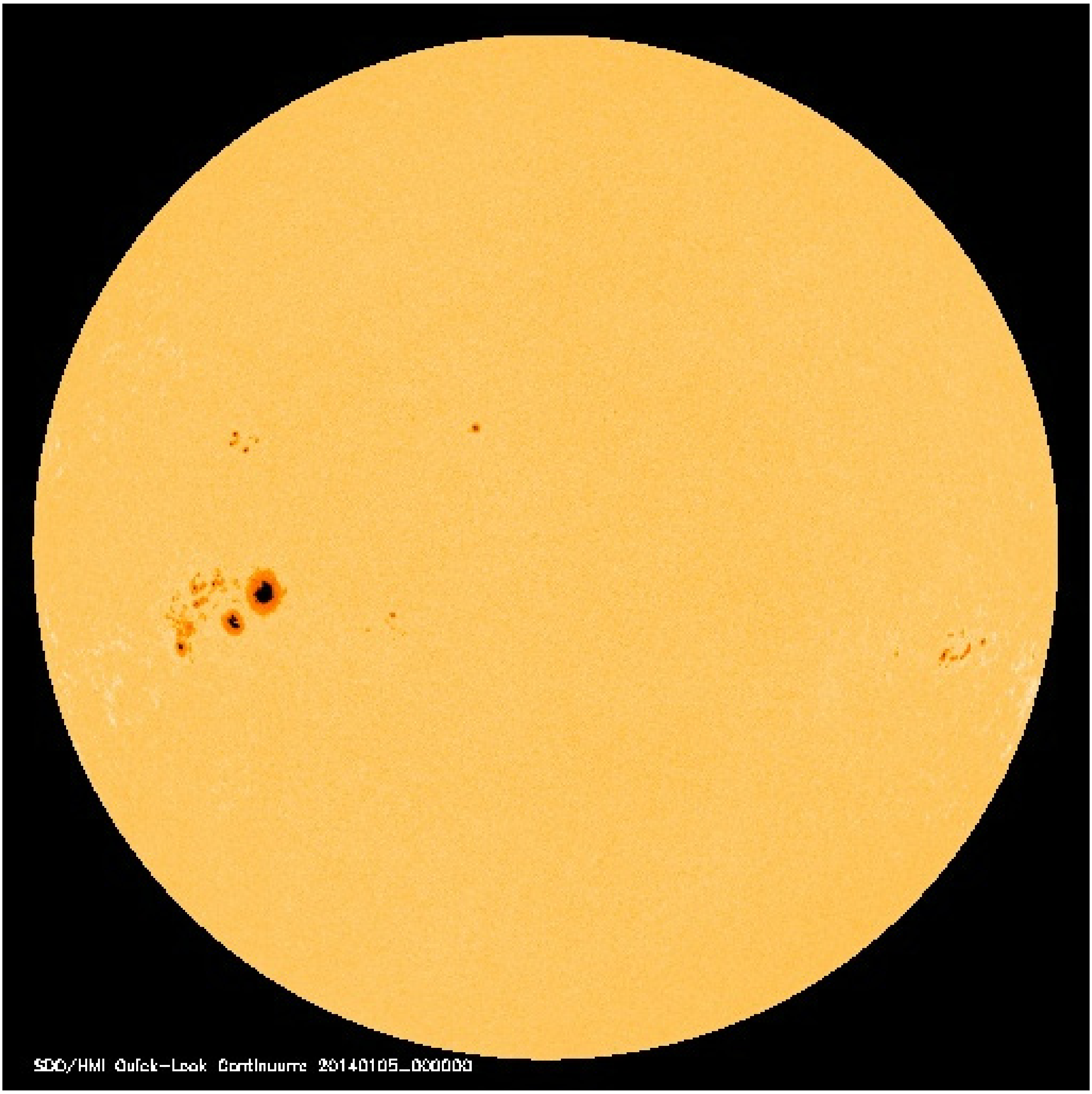


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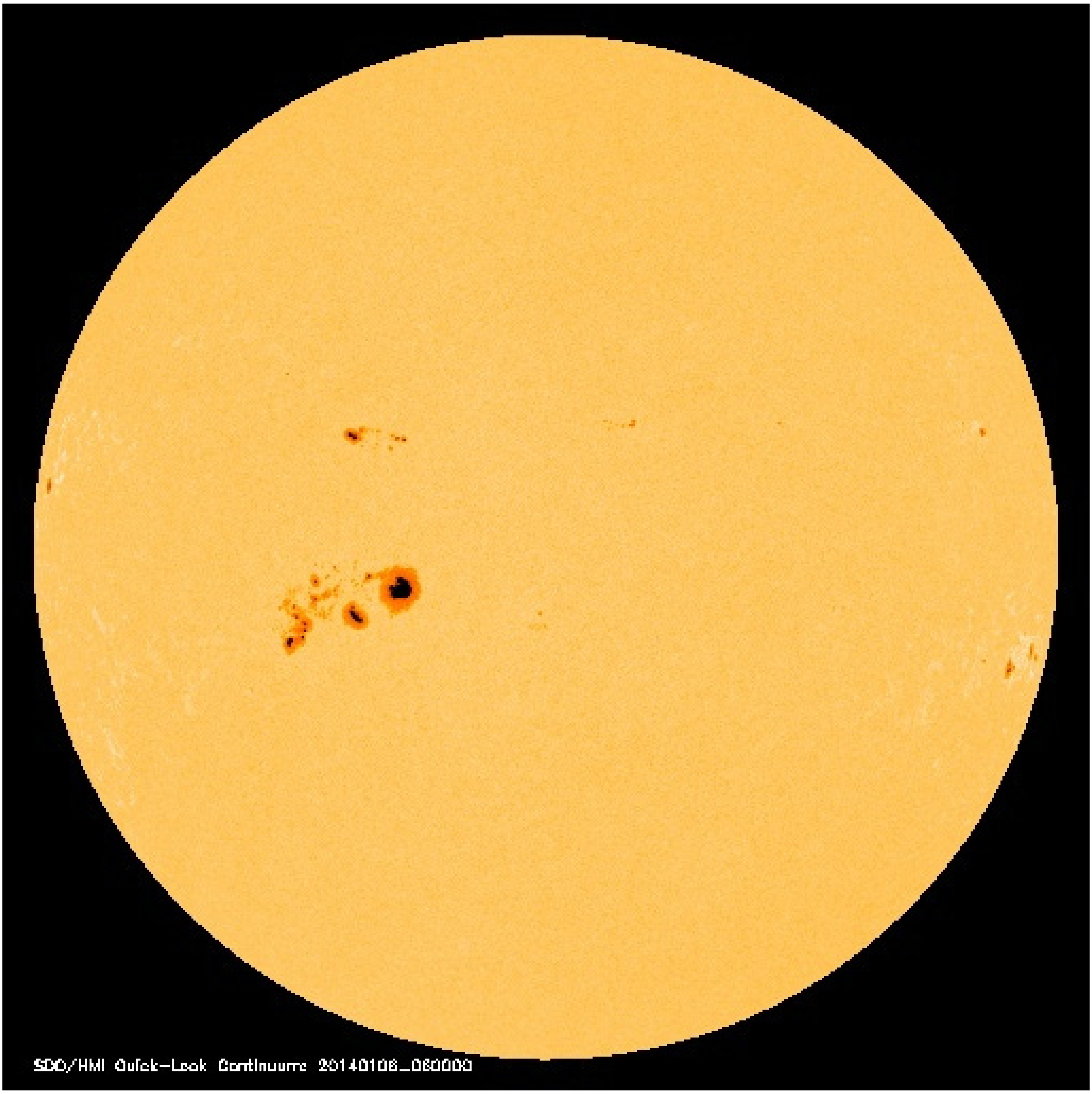


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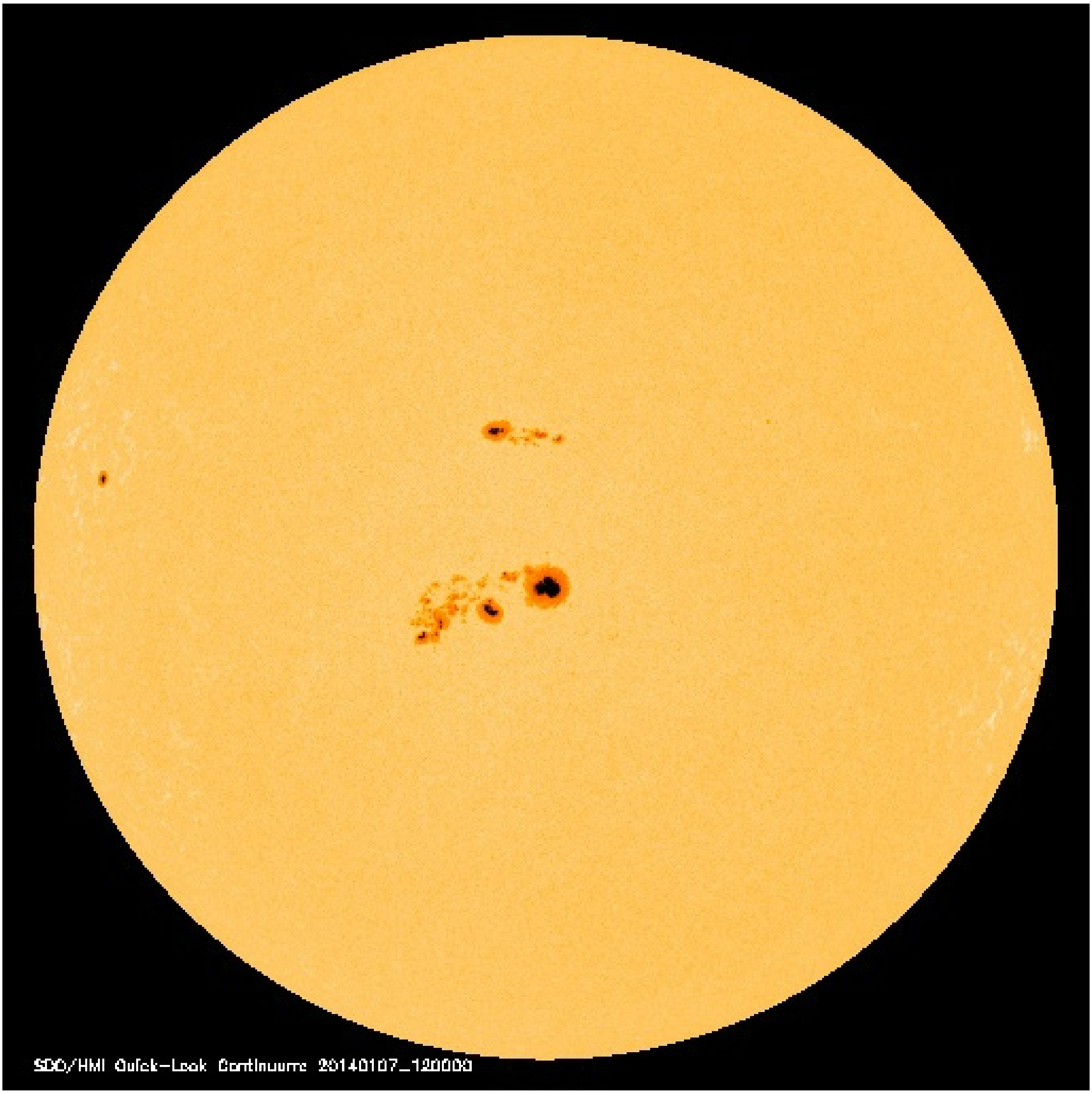


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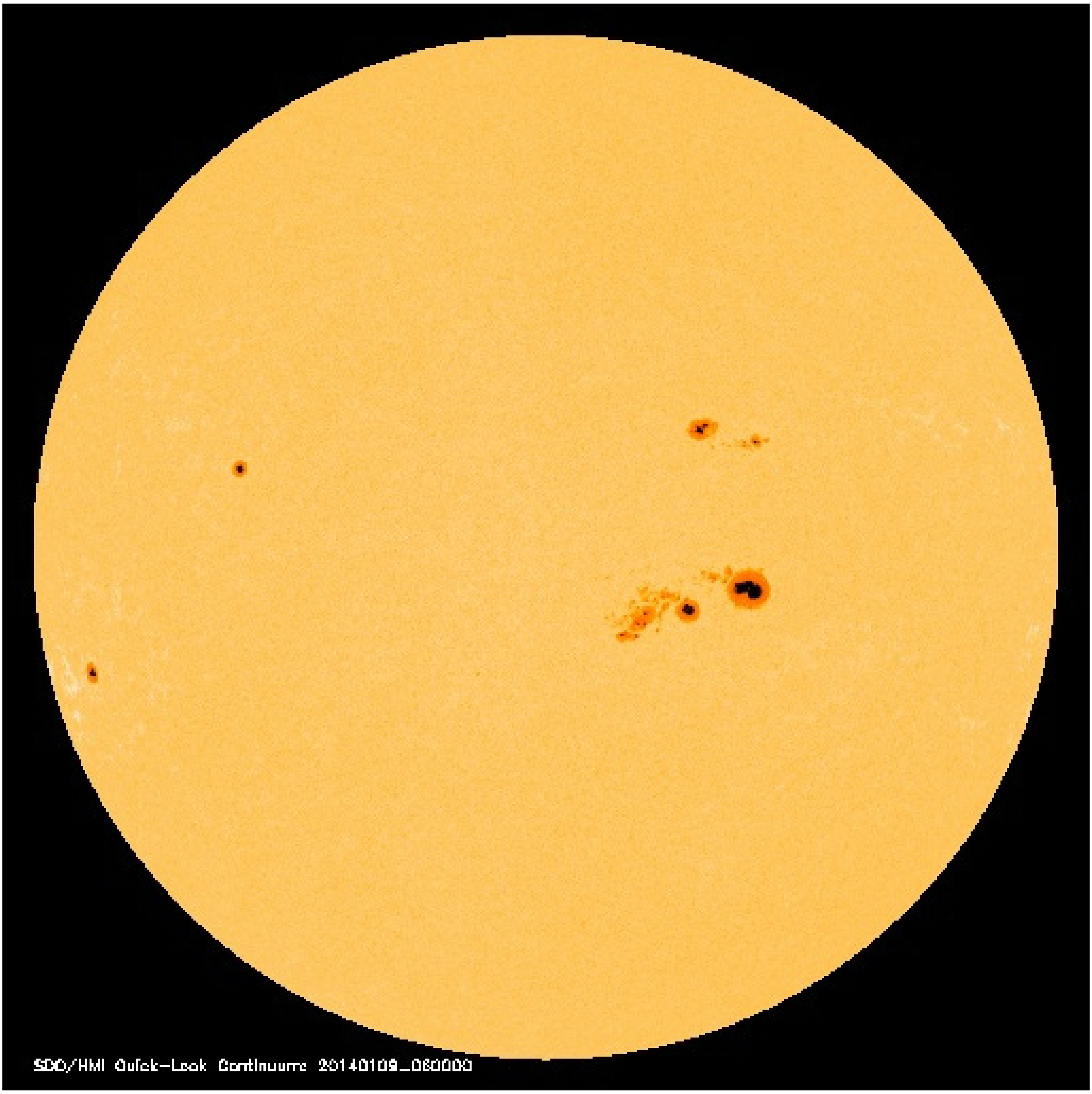


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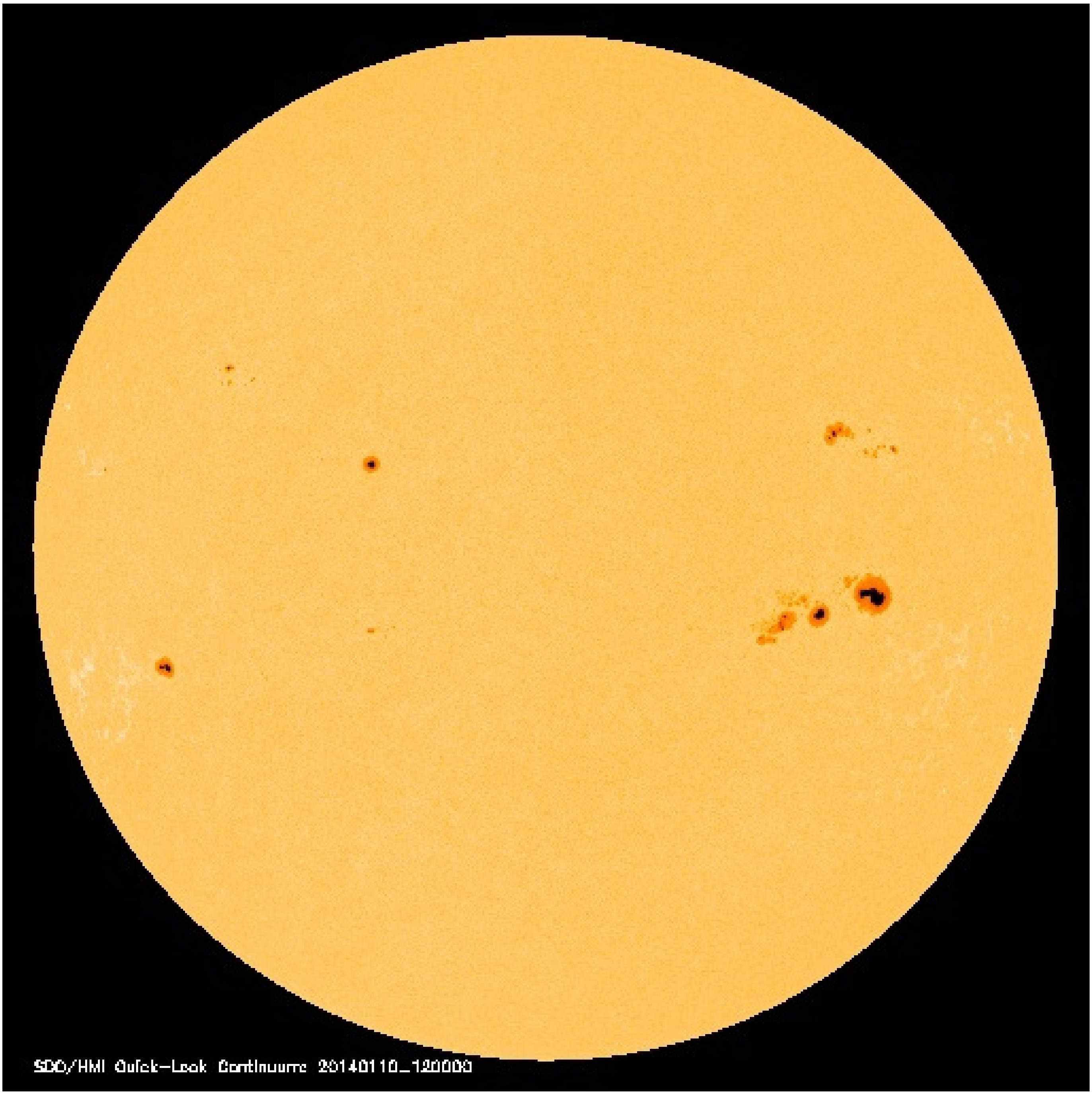


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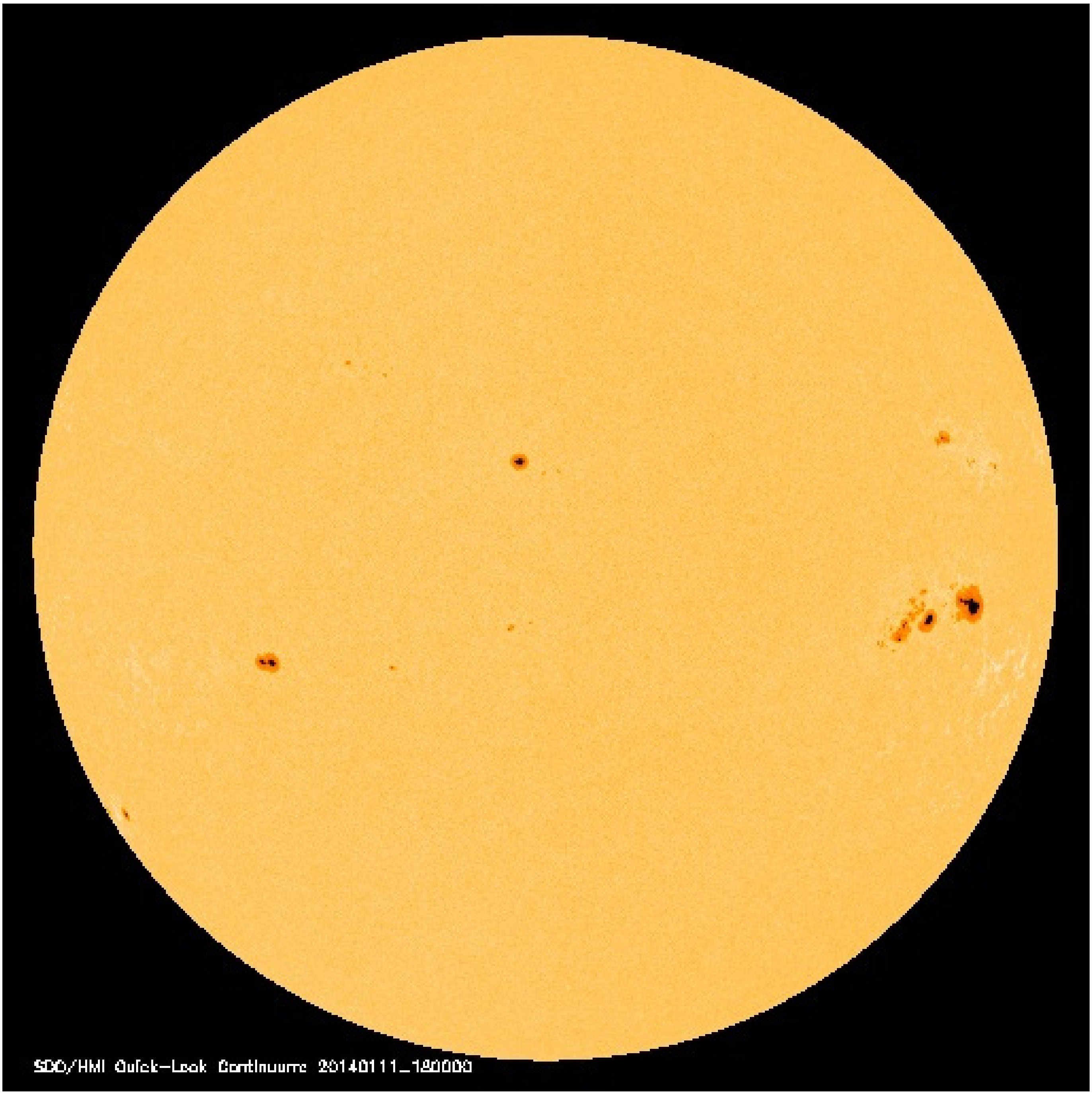


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