Rare first moment of stellar explosion captured by amateur astronomer

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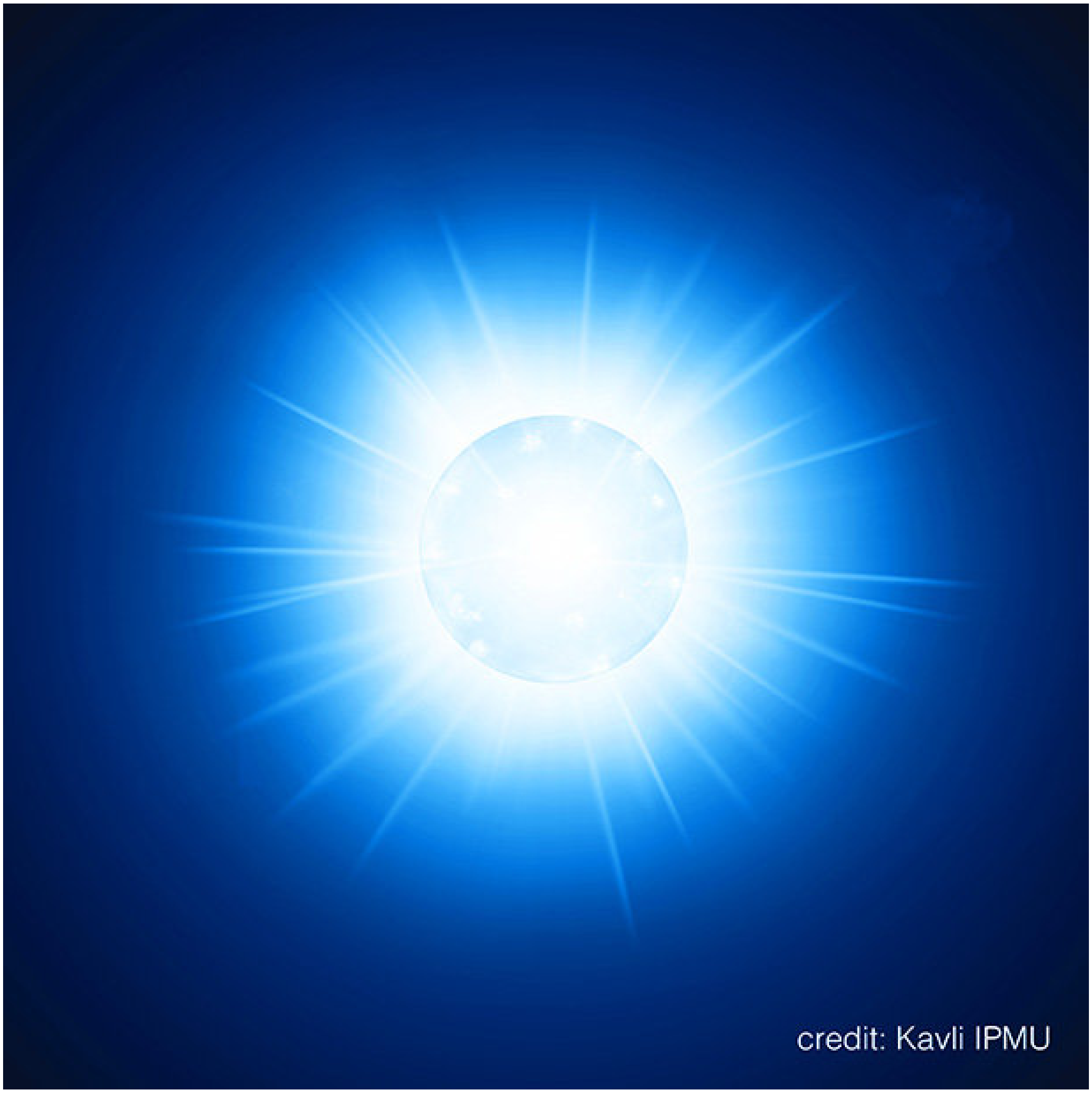


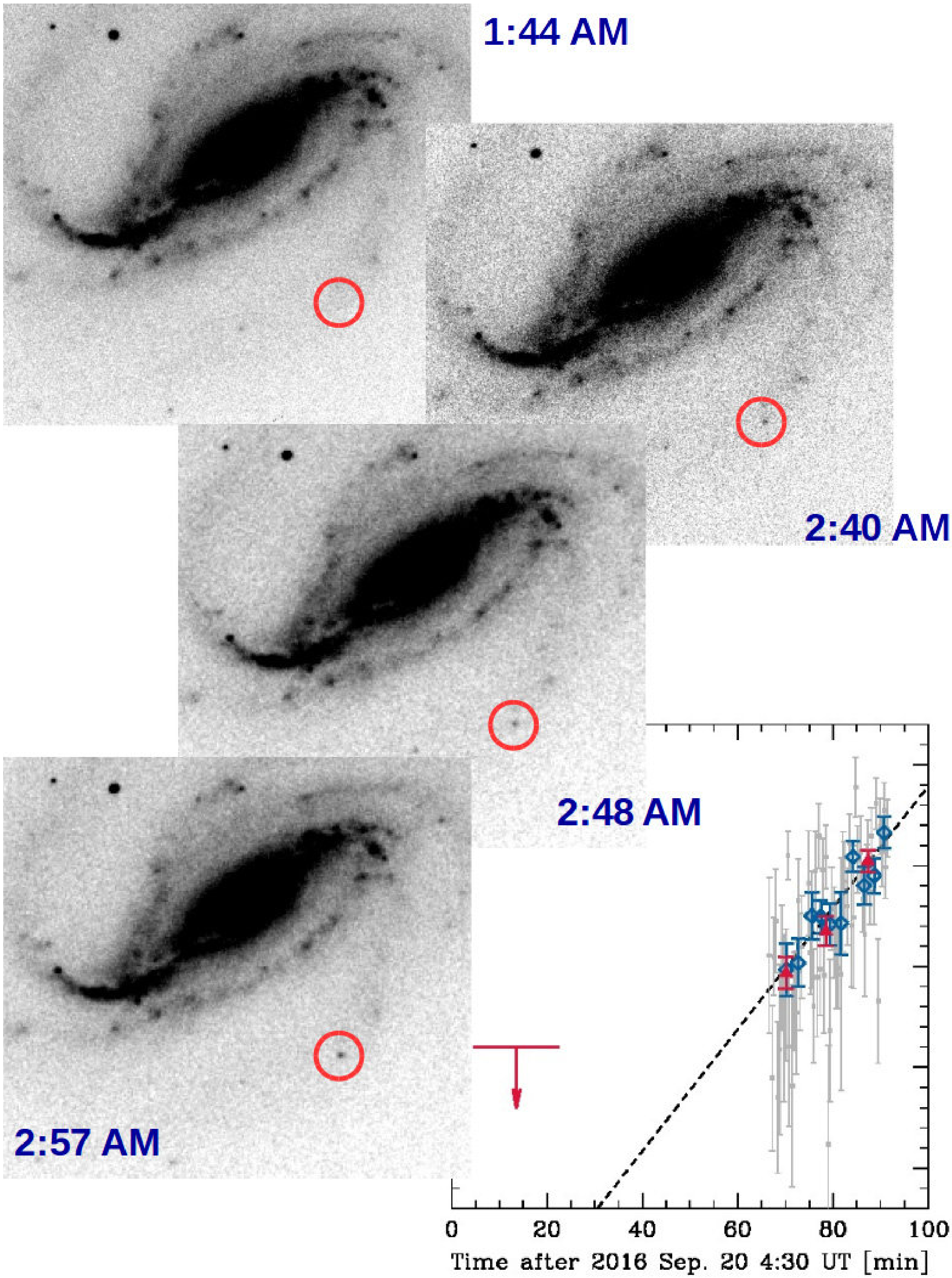
Artist's impression of a shock breakout. Credit: Kavli IPMU

An amateur astronomer testing his new camera captures the moment a supernova became visible in the night sky, which has helped an international team of researchers to test their theory about the beginning stages of a stellar explosion.

The moment a supernova becomes visible in the sky has been captured by an amateur astronomer, and has helped an international team of researchers validate theoretical predictions about the initial evolution of such stellar explosions.

How the structure of the exploding star affects the supernova properties has remained an open question, but understanding it would be a significant step forward in astrophysics research. Current theory suggests an explosive shockwave travels through the star's interior before reaching the surface and producing a sharp peak of electromagnetic emission. The strength and duration of this signal, known as shock breakout is believed to largely depend on the outer structure of the star and on the presence or absence of matter around it. However, testing this theory requires the observation of the before and after moment a star becomes a supernova.

Melina Bersten, researcher at the National Scientific and Technical Research Council-Argentina, and Visiting Associate Scientist at the Kavli Institute for the Physics and Mathematics of the Universe has said the chances of capturing such an event are slim, because it lasts for the order of one hour.


1:44 AM
2:40 AM
2:48 AM
2:57 AM
0
20
40
60
80
100
Time after 2016 Sep. 20 4:30 UT [min]

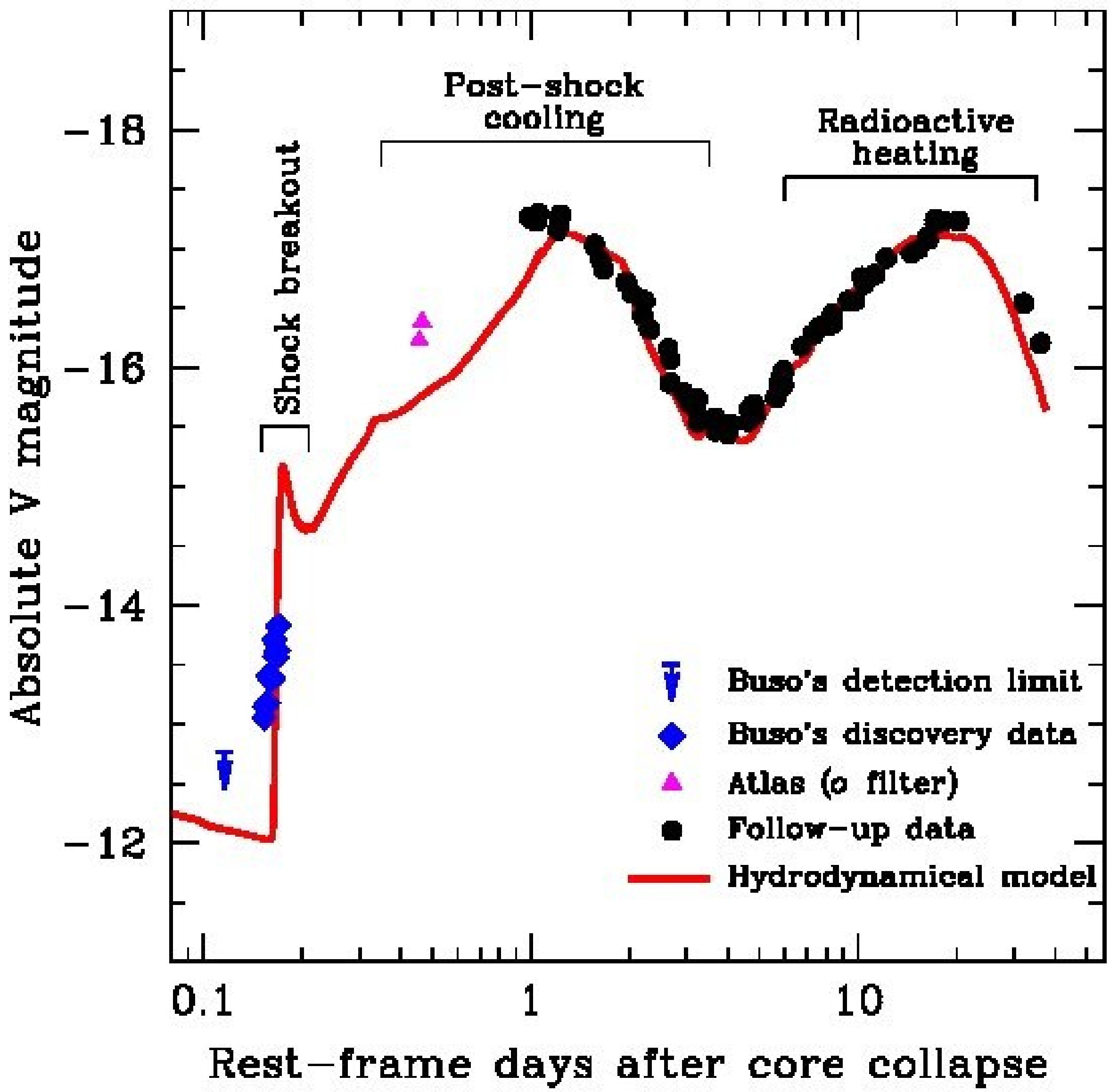
Sequence of combined images obtained by Víctor Buso as SN 2016gkg arises in the outskirts of galaxy NGC 613. Labels indicate the time each image was taken. The supernova location is indicated by the red circles. Notably the supernova appears and steadily brightens within one hour, as shown in the lower-right panel. Credit: Bersten et al.

"If we think that on average each galaxy roughly produces one supernova per century, and that a century contains nearly 900 thousand hours, then the chance probability of observing the right galaxy at the right moment is not much greater than one in a million. However, the actual chances are smaller. One needs to take into account the facts that we can only see the galaxy during the night time and that the sky must be clear," she said.

Luckily, on September 20, 2016, amateur astronomer Víctor Buso from Rosario, Argentina, was testing his new camera on his rooftop observatory in hope of photographing his first supernova. After an hour of taking images Buso noticed a new tiny object had appeared, and it became more obvious with time (Figure 1). He had captured the moment a supernova had exploded.

Named SN 2016gkg, a team of researchers including the Kavli Institute for the Physics and Mathematics of the Universe, and lead by Bersten, analyzed the images. The rapid brightening rate combined with a very low luminosity had no analogue among known supernovae, and the team concluded Buso had discovered SN 2016gkg during the shock breakout.

"When Buso told us how he had observed and what he had witnessed, we realized this was a unique finding," said Bersten.



Observed light curve of SN 2016gkg (dots) and explosion model (red line). The model reproduces three distinct phases in the supernova evolution that occur on different time scales. First, the shock breakout (with a time scale of hours), then the post-shock cooling emission (days), and finally the emission due to radioactive heating (weeks). Buso's discovery observations, shown in blue, indicate such a rapid rise that can only be attributed to the shock breakout. Credit: Bersten et al.

Also, by comparing the photometry of the images with their computer simulations, the team found an initial sharp rise in supernova light that could only be explained by shock emergence (Figure 2).

"To our surprise, images had a great quality considering they were obtained from the middle of a large city in the midst of the pampas", notes Dr. Gastón Folatelli from IALP, who led the data analysis, and adds "sky conditions seem to have been nearly ideal on that night!"

Their conclusion was supported by the fact that the models required no modification in order to consistently reproduce the initial rise and the rest of the supernova evolution (Figure 3). Moreover, SN 2016gkg happened to be a rather ordinary event, which would imply that the observed phase is common to all supernovae, as models predict.

The team's results were published in *Nature* on February 22.

Provided by ResearchSEA