

Stockholm Supernova Stalking

- a pursuit of finding out about
matter, the universe and everything

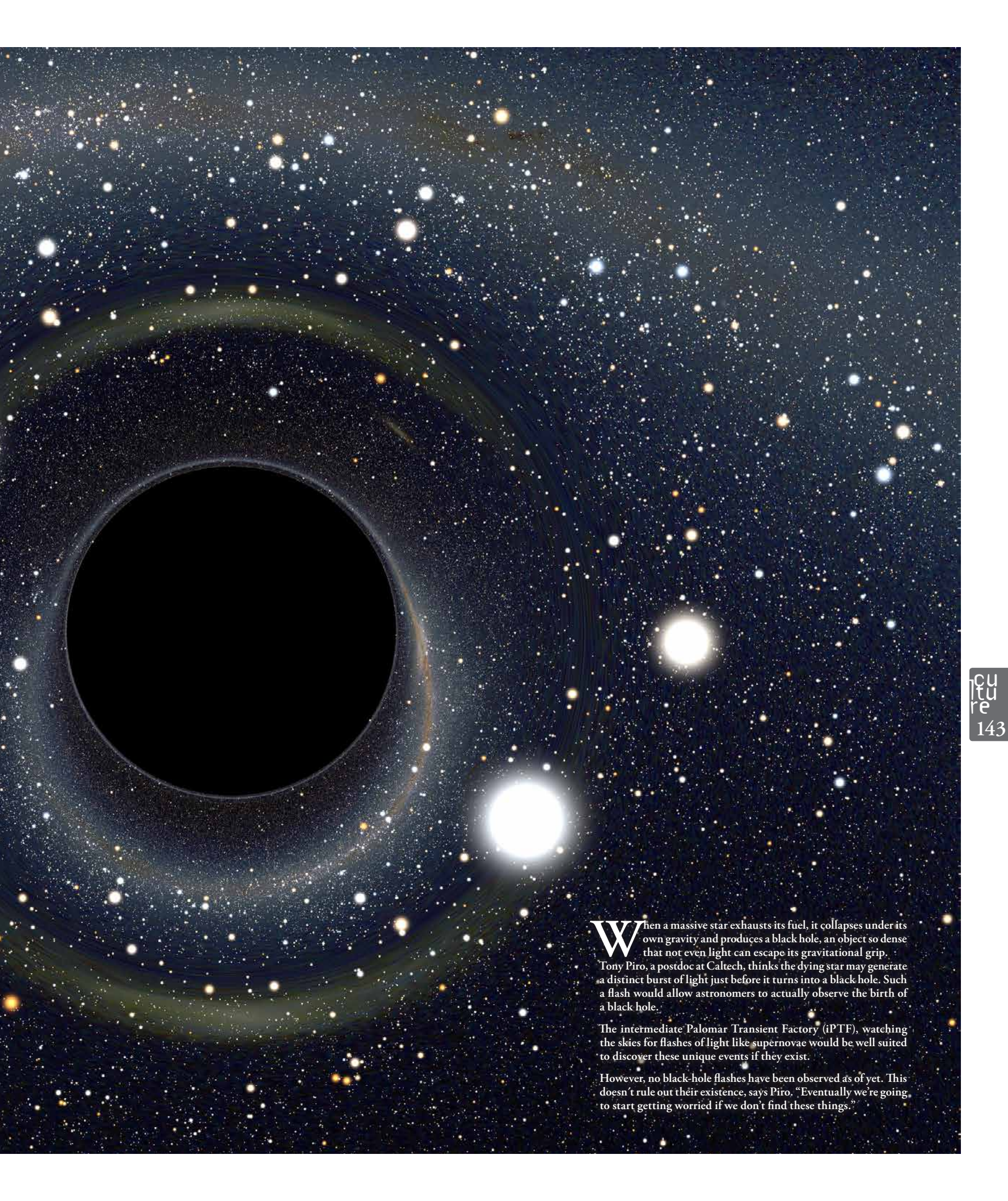
BY SUSANNA KUMLIEN

As robot-sent data of real-time observations arrives from the telescopes at Palomar outside San Diego some 9,000 kilometres away, Jesper Sollerman and his team in Stockholm carefully study measurements for anomalies. They're on a mission to track down supernovae, the massive explosions from which all heavier elements emanate. They even aspire to be able to do this right after the explosions happen.

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Light distortions by a black hole. Artist's impression.
PHOTO: PALOMAR OBSERVATORY, ALAN RIAZUELO, IAP/UPMC/CNRS

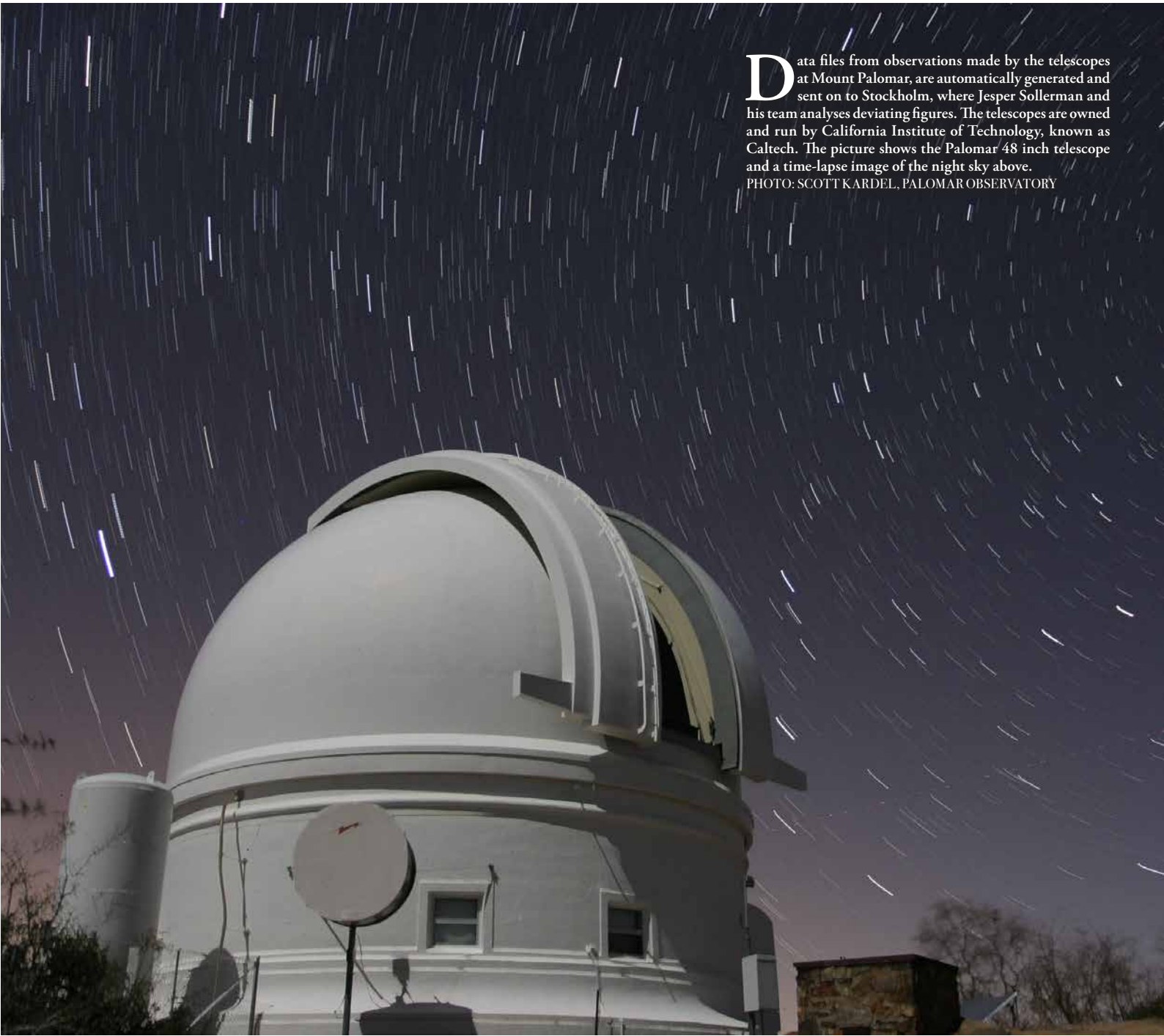




When a massive star exhausts its fuel, it collapses under its own gravity and produces a black hole, an object so dense that not even light can escape its gravitational grip. Tony Piro, a postdoc at Caltech, thinks the dying star may generate a distinct burst of light just before it turns into a black hole. Such a flash would allow astronomers to actually observe the birth of a black hole.

The intermediate Palomar Transient Factory (iPTF), watching the skies for flashes of light like supernovae would be well suited to discover these unique events if they exist.

However, no black-hole flashes have been observed as of yet. This doesn't rule out their existence, says Piro. "Eventually we're going to start getting worried if we don't find these things."



Data files from observations made by the telescopes at Mount Palomar, are automatically generated and sent on to Stockholm, where Jesper Sollerman and his team analyses deviating figures. The telescopes are owned and run by California Institute of Technology, known as Caltech. The picture shows the Palomar 48 inch telescope and a time-lapse image of the night sky above.

PHOTO: SCOTT KARDEL, PALOMAR OBSERVATORY

Residing in the beautifully and daringly designed white AlbaNova building – a late masterpiece by Danish architect Henning Larsen – Jesper Sollerman is studying recent measurements on his computer screen. Professor of Astronomy at Stockholm University and OKC, the Oskar Klein Centre, he is together with some 15 fellow researchers engaged in one of the world’s most intriguing projects within observational astronomy.

A poetic notion of Physics is the fact that we are all star children, as the atoms we consist of emanate from dying stars. Only during their death struggle, the preconditions of temperature and pressure are sufficient enough to release vital elements, such as carbon and oxygen.

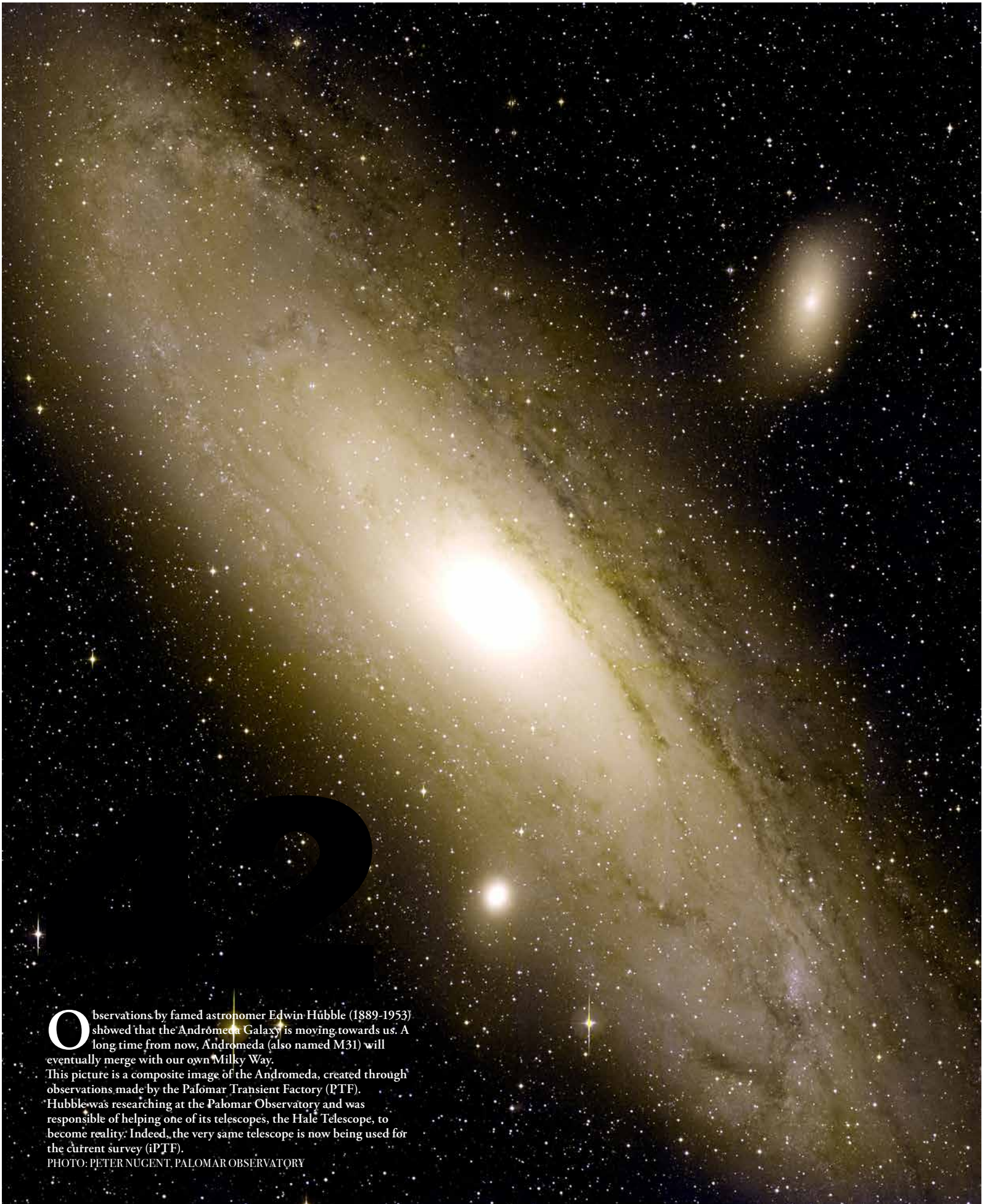
Think about it. Everything oxygen available, for example, has been created inside a massive star and released in a supernova explosion. The more massive the star, the further down in the periodic table the element created in the process of the fierce explosion.

Atoms in your body probably emanate from different stars, too. For example, an oxygen atom in your right leg may very well have been created in a star in a different solar system in another galaxy at a vastly different point in time than an oxygen atom in your toe. The immensely long evolutionary process of star cycles, generations of stars being born and die, goes for the creation of the ingredients of man and matter.

With the exception of the lighter elements hydrogen, helium, lithium and deuterium, which emanate from the Big Bang, the building blocks of anything living on the planet were created in a star. As carbon-based organisms, we owe our very existence to the stars. Or, as Physics Professor and famed atheist Lawrence Krauss loves to put it: “Forget about Jesus. The stars died for you.”

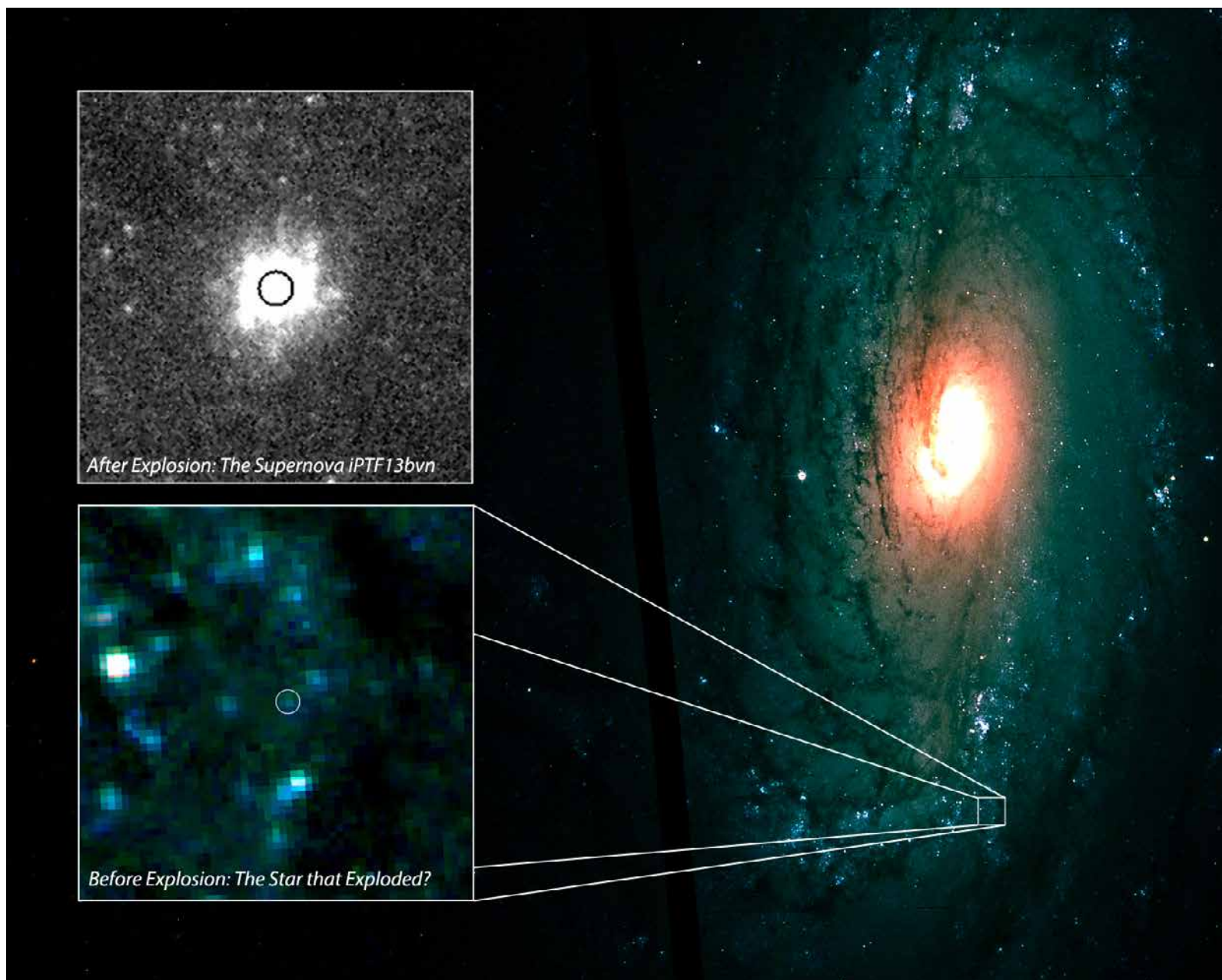
These bewildering and baffling facts of the preconditions for our existence certainly do put things into perspective. Which is one of the many reasons as to why the sudden flare-up of supernovae on the dynamic starry sky is of such interest to Science.

Not only are they spectacular events, but supernovae hold many secrets of great importance for our



Observations by famed astronomer Edwin Hubble (1889-1953) showed that the Andromeda Galaxy is moving towards us. A long time from now, Andromeda (also named M31) will eventually merge with our own Milky Way. This picture is a composite image of the Andromeda, created through observations made by the Palomar Transient Factory (PTF). Hubble was researching at the Palomar Observatory and was responsible of helping one of its telescopes, the Hale Telescope, to become reality. Indeed, the very same telescope is now being used for the current survey (iPTF).

PHOTO: PETER NUGENT, PALOMAR OBSERVATORY



One of the aims of Jesper Sollerman and his team is to find out which type of stars creates which type of supernovae. This composite image shows the supernova iPTF13bvn and its possible progenitor star. It was observed in the galaxy NGC 5806, situated in the constellation of Virgo. PHOTO: PALOMAR OBSERVATORY

understanding of the universe, life and everything. However, scanning the skies for supernovae may seem a bit like looking for a needle in a hay stack to the layman.

First of all, supernovae – or massive star explosions – are extremely rare. A supernova explosion doesn't happen to every star. They occur only once in a hundred years or so in each galaxy. Finding that one specific star which is about to explode within the realms of one galaxy does indeed seem like a tedious task, since there are thousands of millions of star systems within a single galaxy.

Taking into consideration the additional circumstance of the fact of there being hundreds of millions of galaxies, finding supernovae does seem like an almost overwhelming undertaking, on the very edge of human capacity. Or is it?

Jesper Sollerman, Professor at the Department of Astronomy and Oskar Klein Centre of Stockholm University, certainly seems to know what he's doing. Now in his mid-40's, Sollerman is an internationally renowned observational astronomer. He collaborated with the 2011 Nobel Prize winning team and has twice been on journal *Science's* annual top ten list of the most important scientific breakthroughs.

He grew up on the Baltic island of Gotland, reading books on Physics. Not that he recalls any specific book making an impression, but he was fascinated. "I thought I wanted to dedicate myself to Quantum Physics, which I found intriguing, but eventually cosmology took over".

Sollerman likes the notion of not knowing what to find. Perhaps this is why a Swedish magazine recently

referred to him as a "hard-hitting reporter of the skies". Observational astronomy is more action-orientated than the theory of it, and Sollerman found his realm. "I like it when things are happening. Real events are so exciting. I want to find out how they happen, why and when".

Recently, he and his team received a grant for their supernova stalking from the Knut and Alice Wallenberg Foundation. The 33 MSEK will now allow OKC's astronomers and physicists to play a leading role in the project as it proceeds into its next phase.

"Our research team will look for supernovae in a new way. All researchers who want to study a star's death face the challenge of supernova explosions being uncommon. We must therefore observe many galaxies. The unique feature of our project is that we scan the same part of the sky



The astronomical object M101, also known as the Pinwheel Galaxy, is a spiral galaxy located in Ursa Major at a distance of approximately some 21 million light years. This composite picture shows M101 before and after a supernova detected by the Palomar Transient Factory, PTF11kly, exploded.
PHOTO: PALOMAR OBSERVATORY, BJ FULTON

Byrne Observatory at Sedgwick Reserve and the Palomar Transient Factory | LCOGT

more often. In this way, we find supernovae shortly after they exploded.”

Since last year, the Stockholm team is part of a global enterprise, involving researchers from all over the globe. Ever since 2009, PTF – the astronomical wide-field survey Palomar Transient Factory – has successfully been scanning the sky through observations by its telescopes in California.

“The best part of it is that we are spread all over the globe, so someone is always looking through the data. And that our automated processes allow for an unprecedentedly systematic scanning of the skies.”

Designed to search for optical transient sources, the PTF is fully automated and includes a wide-field survey camera, an automated real-time data reduction pipeline, and a dedicated photometric follow-up telescope. Telescopes are at Mount Palomar outside San Diego in California, owned and operated by California Institute of Technology, more known as Caltech.

The problem with observing supernovae is knowing

when and where one is to occur. Sollerman and his team intend to find them on the very first night. “As a rule, previous supernova surveys have discovered supernovae days or weeks after the explosion. We plan to change all that.”

Finding supernovae at the optimal moment, just after the explosion, means their properties can be investigated more thoroughly. What type of star gives birth to what kind of supernova?

Photos taken before and after the explosion will disclose yet unseen data. The method of image subtracting is being used, a process where digital numeric values of a picture are subtracted from the previous image, thus detecting any changes between the two.

Using this technique, systematic observations bring about 20,000 reports a day to the Stockholm team. An advanced software rules out the vast majority of data. Sollerman points at his screen as he explains: “Out of what remains, there are usually about 30-35 or so potential candidates to have a closer look at

manually. Every week we have a meeting where we discuss candidates of interest, out of which some are chosen for closer investigative measures.”

The systematic approach was proven fruitful earlier this year, as a new supernova was discovered in March. One of the first studies of the new finding was conducted by Ariel Goobar, another member of the Stockholm team. The discovery made world news, and the eager reader of *Loft Bookazine* may recall a tidbit on the topic (Volume 1, 2014).

The supernova in the galaxy of M82, also known as the Cigar Nebula, proved to be a Type Ia-supernova, a so-called Standard Candle. A Standard Candle is an object astronomers can use to measure distances in the universe, taking advantage of its known properties.

With its distance from Earth of only some 12 million light years, considered to be “nearby” by cosmological standards, the supernova’s proximity allowed astronomers to study the supernova over a wide wavelength range, just hours after the deduced explosion time.

The Stockholm OKC astronomers use telescopes



Professor Jesper Sollerman is taking part in developing a new camera for the Zwicky Transient Facility (ZTF), a new time-domain survey to be launched in 2016. The new camera will have a 47 square degree field of view and its extremely wide field and fast readout electronics will enable a survey more than an order of magnitude faster than previously possible. By scanning almost 4,000 square degrees an hour, ZTF will be able to discover a supernova less than 24 hours after its explosion. It will also search for rare and exotic transients. Repeated imaging of the Northern sky will produce a photometric variability catalog with of some 300 observations annually. PHOTO: SUSANNA KUMLIJEN

on Mount Palomar outside San Diego, owned and operated by Caltech. One of them is the Hale Telescope, that none less than Edwin Hubble, the famed astronomer, helped develop.

When the 200-inch telescope was completed in 1948, Hubble was the first person to use it. At the time, a BBC reporter asked Hubble what he was hoping to find with the immense telescope. "We hope to find something we hadn't expected," Hubble replied. The very same Hale Telescope is now being used by Sollerman and his team.

"The telescopes aren't the most modern or largest, but we compensate that with our methods of systematic approach and our automated processes. A robot server is strenuously sending instructions telling the telescope what to do at night," says Sollerman.

He and the team are also granted the highly

valuable privilege of observational time with the Hubble telescope and VLT, Very Large Telescope, in Chile.

"Our goal is to always have at least one large telescope ready when we have readings indicating an upcoming event. Other ongoing observations being overruled by our request, it is indeed a privilege that comes with responsibilities."

Sollerman recently arranged a meeting with the PTF regarding the next phase of the project. Among other things, they were discussing how to get an array of 16 detectors going for their mission.

The near future is set for the Swedish professor, as it involves the construction and building of a new camera. The so-called Zwicky Transient Facility or ZTF, is to be launched at Palomar Observatory in 2016.

The new camera will have a 47 square degree field

GLOSSARY:

PTF = Palomar Transient Factory

Transient = A transient event in Physics is a short-lived burst of energy in a system, caused by a sudden change of state.

iPTF = intermediate Palomar Transient Factory

OKC = The Oscar Klein Centre. A centre for research in Physics at Albanova in Stockholm, where also the largest auditorium is named after Oskar Klein.

OSKAR KLEIN (1894-1977)

Oskar Klein was a Swedish theoretical physicist who worked with Niels Bohr and received a professorship in Ann Arbor, Michigan. Later he returned to Sweden and was awarded the prestigious Planck Medal. Klein is credited for inventing the idea that extra dimensions may be physically real, although "curled up", an idea essential to string- and M-theory. He did this in the 1920s. In the 1930s, he suggested a boson-exchange model for weak interactions.

WHY THE 'M' IN M82?

When astronomical objects are named M with a number, it means the object is included in the Messier catalogue. Charles Messier (1730-1817) was a French astronomer who catalogued astronomical objects. His purpose was to help astronomical observers distinguish between permanent and transient visually diffuse objects in the sky. The M82 was one of the last objects to be included in this catalogue, in 1781. Messier himself wasn't at all interested in stars or supernovae, but was looking for comets.

LATEST SUPERNOVA IN OUR GALAXY:

The most recent supernova to be observed in our own galaxy the Milky Way, was the so-called Kepler Star in 1604. Some 30 years before, a supernova in the constellation of Cassiopeia was described by Tyge Brahe, father of observational astronomy. His book on observations of the supernova of 1572, De Stella Nova, was of great significance and the first step towards modern Science.

LINK

The Palomar Transient Factory: Follow the discovery of supernovae at frequently updated <http://www.ptf.caltech.edu/iptf/>

of view. The extremely wide field combined with its fast readout electronics will enable a survey more than an order of magnitude faster than previously possible. By scanning almost 4,000 square degrees an hour, ZTF will be able to discover a supernova less than 24 hours after its explosion. It will also search for rare and exotic transients.

Not unlike something Edwin Hubble would have said, Sollerman concludes:

"We also hope to discover some astronomical sources not previously observed. Cosmic explosions of the more short-lived type that flares up in just a few hours have not been studied previously," says Jesper Sollerman, not knowing what to find. But eager to find out. ■