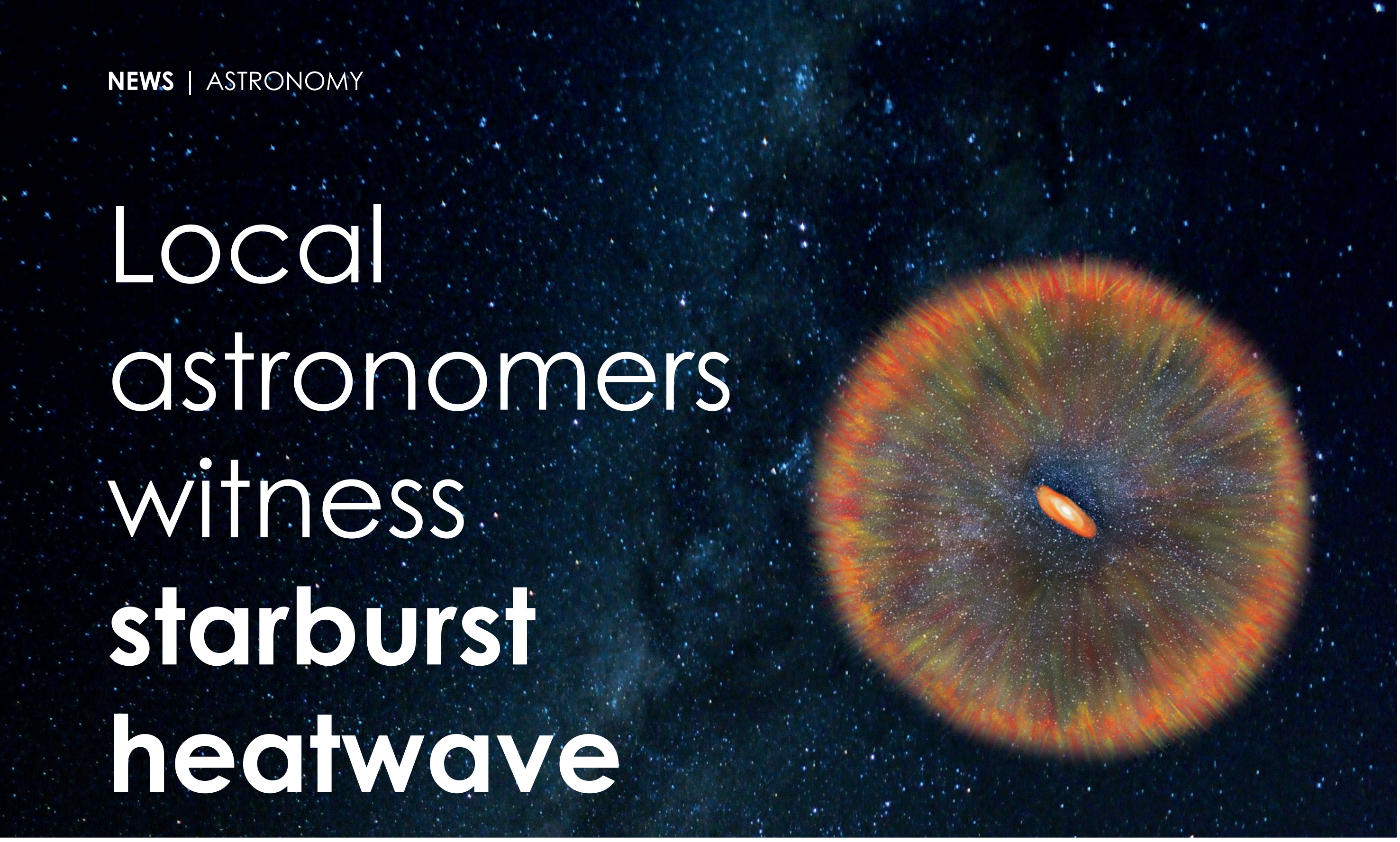


# Local astronomers witness **starburst heatwave**

*Katharina Immer*

**Artist's impression**

**Astronomers from the Hartebeesthoek Radio Astronomy Observatory (HartRAO) and the Centre for Space Research at North-West University (NWU) were part of an international collaboration monitoring a 'heatwave' of thermal energy that radiated outward from a massive young star, or protostar.**

Nobody knows how some stars grow to have a mass that is tens to hundreds of times greater than the sun's. Protostars can't be observed with optical telescopes because they're shrouded by a molecular cloud composed of gas and dust, which over time collapses inwards under gravitational and frictional forces, building up the central star body in a process called disc-aided accretion. One theory proposes that high-mass protostars gain most of their mass in short intense bursts of accretion, or 'episodic accretion', followed by long periods of inactivity, possibly lasting hundreds to thousands of years.

Fortunately, protostars can be investigated by studying their masers – an acronym for 'microwave amplification by stimulated emission of radiation'. These spectral line emissions arise from molecules such as water ($H_2O$), methanol ($CH_3OH$), hydroxyl (OH), formaldehyde ($CH_2O$) and ammonia ($NH_3$) in the protostars' molecular clouds.

In 2006 a high-mass protostar named G358 was discovered during a galactic plane survey of 6.7 GHz methanol maser emissions. The find was unremarkable, however, as it was just one of almost a thousand sources observed, and it warranted one of the briefest entries in the notes published on the survey results. But in January 2019, astronomers from Ibaraki University in Japan noticed a flaring of G358's methanol masers, indicative of a potential accretion burst. They alerted the Maser Monitoring Organisation (M2O), a global community of scientists involved in maser-driven astronomy, which mobilised quickly to study the emissions.

Dr Ross Burns of Japan's National Astronomical Observatory leads M2O, and explains the benefits of the collaborative approach.

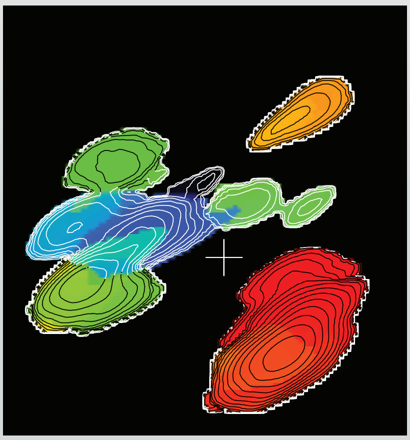
"Each radio observatory is different and each has its advantages and limitations. Typically, each will have a few receivers that detect radio emission at various frequency ranges. The 6.7 GHz methanol maser is a reliable and bright maser, but there are hundreds of masers of different molecules and different frequencies. So each observatory will be able to observe some, but not all masers. By establishing a communication network between radio observatories, the M2O can coordinate efforts so that as many maser lines as possible are observed when a source is bursting."

Indeed, over the next few months many new maser lines were discovered. The main maser spot, dubbed G358-MM1, was imaged using very-long-baseline interferometry (VLBI).

"In short, a collection of radio observatories record data at very high time resolution for the same source at the same time. Those data sets are synchronised and

**Data image showing a methanol maser emission, which traces the heatwave as it propagates outward from the position of the high-mass protostar, represented by the white cross. The colours indicate the velocity of the gas motion in the direction of the observer's line of sight.**

*NAOJ/Burns et al. 2020*



combined such that the signals interfere with each other, hence the name interferometry," explains Dr Ross. "In this way we can establish the shape of the emission that produces the signal."

The data image shown here was made using several radio telescopes in Australia and New Zealand, as well as South Africa's HartRAO. The team compared multiple images spaced a few weeks apart to reveal the 'heatwave', which was later confirmed by SOFIA to originate in an accretion event. SOFIA − the Stratospheric Observatory for Infrared Astronomy − is a Boeing 747SP modified to carry a 2.7 m reflecting telescope. Flying the plane almost 14 km above the Earth's surface puts it above 99% of the infrared-blocking atmosphere, allowing astronomers to study the solar system and beyond in ways that are not possible with ground-based telescopes.

"The M2O observations are the first to witness the immediate aftermath of an accretion burst in a high-mass protostar in such detail, which provide evidence in support of the `episodic accretion' theory of high-mass star formation," says Dr Burns. "Our team greatly benefits from close communication between a diverse, global community of observers, astrophysicists and theorists in planning, executing and interpreting transient maser events."

The input of these specialists is reflected in the authorship of the paper describing the heatwave, which was published in *Nature Astronomy* in January 2020. There are 23 authors representing 15 countries, and three of them are from South Africa – Dr Gordon MacLeod, previously affiliated to HartRAO but now at the University of Western Ontario in Canada, Dr Fanie van den Heever, a postdoctoral fellow at HartRAO, and Associate Professor James Chibueze of the NWU's Centre for Space Research. All three were also among the numerous co-authors on another paper, with Dr MacLeod as lead author, focusing largely on observations conducted with HartRAO's 26 m telescope to confirm the flaring of the 6.7 GHz methanol masers, and to search for hydroxyl, formaldehyde, water and other methanol masers.

"It is a privilege to be at the cutting edge of humanity's efforts to understand space and celestial bodies, and to have witnessed star behaviour that is entirely new," says Prof. Chibueze. "The team's discoveries are hugely exciting and we are hopeful that further investigation will reveal more about the physical processes taking place within the G358 star. New horizons are opening up in space and it is wonderful that NWU and South Africa are part of it."


- Burns RA, Sugiyama K, Hirota T et al. A heatwave of accretion energy traced by masers in the G358-MM1 high-mass protostar. *Nat. Astron.* (2020) https://doi.org/10.1038/s41550-019-0989-3


**CURRICULUM CORNER**

**PHYSICAL SCIENCES: GRADE 12**

Emission and absorption spectra

## Africa's first PhD in indigenous knowledge of astronomy

**Dr Motheo Koitsiwe at the graduation ceremony.**

For centuries, people in Africa have measured time, seasons and direction by the stars, and now the North-West University (NWU) has conferred the continent's first PhD in Indigenous Knowledge Systems (IKS) focusing on African indigenous astronomy. Dr Motheo Koitsiwe received his degree in October at the NWU campus in Mahikeng.

In his doctoral research, Dr Koitsiwe investigated African indigenous astronomy of the Batswana in Botswana and South Africa. The study revealed that the Batswana use their indigenous knowledge of celestial bodies for agriculture, natural disaster management, reproductive health, navigation, time calculation, calendar-making, as well as rainmaking and thanksgiving ceremonies. Traditional songs, poems and indigenous games are also used to transmit knowledge of celestial bodies to younger members of the community, to preserve it for posterity.

Dr Koitsiwe developed his passion for IKS research, and especially for indigenous astronomy, early in his academic career. "This passion was ignited by my late grandmother, Mmamodiagane Tladinyane, when she narrated stories, poems, riddles, songs of African night skies and cosmologies around the fireplace," he explains.

The NWU's campus in Mahikeng is the pioneer of IKS in South Africa, because in 2001 it was the first higher education institution in the country to have a registered teaching, learning and research programme in IKS, accredited by the South African Qualification Authority (SAQA).

According to Prof. Mogomme Masoga, who co-supervised Dr Koitsiwe's doctoral studies, his student's thesis had originality and novelty.

Dr Koitsiwe also holds a BA degree in social sciences, as well as an honours and a master's degree in IKS from the NWU. He plans to translate his thesis into Setswana so that it not only reflects the aspirations of academia, but the Bakgatla-Ba-Kgafela and Batswana in general.