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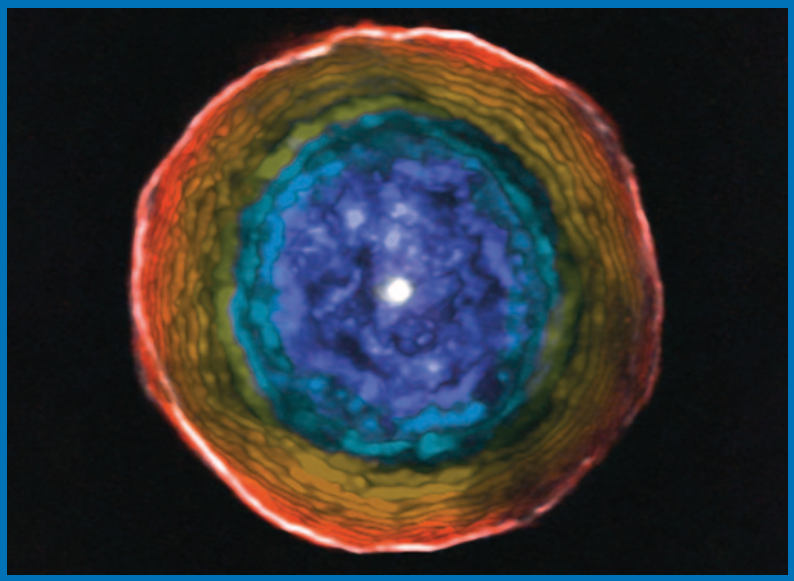
Why Galaxies Care About AGB Stars: A Continuing Challenge through Cosmic Time

Edited by

Franz Kerschbaum
Martin Groenewegen
Hans Olofsson



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WHY GALAXIES CARE ABOUT AGB STARS:
A CONTINUING CHALLENGE THROUGH COSMIC TIME

IAU SYMPOSIUM 343

COVER ILLUSTRATION: THE DETACHED GAS SHELL OF U ANTLIAE

Mass loss during the AGB phase is critical for the evolution of the star itself as well as for the chemical evolution of the hosting galaxy. During the last years, observations have revealed that its temporal evolution, the structure and dynamics of its extended atmosphere, and the chemistry related to molecule and dust formation are more complex than originally thought. As an example, the detached shell surrounding the carbon star U Antliae as observed by ALMA is shown.

Credit: ALMA (ESO/NAOJ/NRAO/F. Kerschbaum)

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Chief Editor
PIERO BENVENUTI, IAU General Secretary
IAU-UAI Secretariat
98-bis Blvd Arago
F-75014 Paris
France
iau-general.secretary@iap.fr

Editor
MARIA TERESA LAGO, IAU Assistant General Secretary
Universidade do Porto
Centro de Astrofísica
Rua das Estrelas
4150-762 Porto
Portugal
mtlago@astro.up.pt

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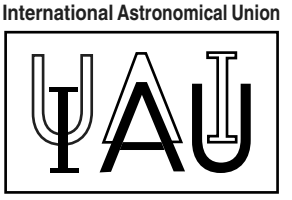

WHY GALAXIES CARE ABOUT AGB STARS: A CONTINUING CHALLENGE THROUGH COSMIC TIME

PROCEEDINGS OF THE 343rd SYMPOSIUM OF THE INTERNATIONAL ASTRONOMICAL UNION HELD IN VIENNA, AUSTRIA 20–23 AUGUST, 2018

Edited by

FRANZ KERSCHBAUM
University of Vienna, Austria

MARTIN GROENEWEGEN
Royal Observatory of Belgium

and

HANS OLOFSSON
Chalmers University of Technology, Sweden

Editorial Assistant

Verena Baumgartner
University of Vienna, Austria

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Preface

Stars are the main components of galaxies, and the sites of the creation of most chemical elements in our universe. As such they are among the most important ingredients in our physical description of the Universe. Due to their high luminosity and production of heavy elements and cosmic dust, stars on the Asymptotic Giant Branch (AGB) play an important role in their capacity as both actors and probes. In addition, AGB stars are prime laboratories for studying complicated physics, such as hydro-dynamical instabilities, double-shell nuclear burning, and dynamical atmospheres where physical and chemical processes, active on different temporal and spatial scales, are at work simultaneously. Understanding these stars sheds light on different processes of great relevance to the understanding of stellar and galactic evolution in general.

Our IAU symposium follows in the tradition of great symposia like *Planetary Nebulae* (No. 155, Innsbruck, 1992), *The Carbon Star Phenomenon* (No. 177, Antalya, 1996), *Asymptotic Giant Branch Stars* (No. 191, Montpellier, 1998), and several other symposia related to variability research or the stellar content of galaxies which had AGB stars as important subtopics. In 2006, a new series of conferences under the main title *Why galaxies care about AGB stars* was initiated with the aim to bring two normally separated communities together, namely those studying the AGB proper and those interested in the evolution of galaxies. Already the first incarnation of the series held in Vienna, 2006 under the subtitle: *Their importance as actors and probes* saw a good acceptance by the community. It was followed by the 2010 conference *Shining examples and common inhabitants* and the 2014 one named *A closer look in space and time.*

The growing interest in these conferences triggered the formation of an international SOC comprising scientists covering a wide range of scientific backgrounds and working on all continents with the purpose of proposing an IAU symposium following this successful tradition for the IAU General Assembly to be held in Vienna in 2018. It should extend this interdisciplinary approach to an even wider community.

Following endorsement and sponsoring by IAU Commissions and Divisions and subsequent approval by the IAU Executive Committee in 2017, speakers were invited and the community at large informed. The overwhelming, positive response materialized into the impressive programme we now have.

It is a great pleasure to acknowledge the financial support of our sponsors, the active support of the members of the SOC and LOC in coping with the big challenges and realizing the numerous details always associated with such a symposium. Especially we would like to thank Verena Baumgartner for her invaluable work as editorial assistant for these proceedings.

Its is our hope that these proceedings will provide a useful resource for experts as well as newcomers to the field.

Franz Kerschbaum, Hans Olofsson, and Martin Groenewegen, editors of these proceedings.

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CONFERENCE PHOTOGRAPH

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Address by the Scientific Organizing Committee

Dear colleagues,

also from us a warm welcome to this IAU Symposium No. 343. We are delighted to see you all here in the beautiful city of Vienna during the 30^{th} General Assembly of the International Astronomical Union. Vienna has already a long tradition in stellar astrophysics and hosted several successful symposia and conferences in the field and especially the very topic of our meeting, namely Asymptotic Giant Branch (AGB) stars. Many of us remember the AGB meetings in 2006, 2010 and 2014!

Symposium 343 builds a bridge between research on AGB stars themselves and its application to the modelling of stellar populations and the chemical evolution of galaxies and the Universe as a whole. Current developments and challenges seen from both domains are discussed to reach an understanding of possibilities, limitations, and needs in both areas, and hence to improve our understanding of the role of AGB stars in the context of galaxies over cosmic time. Despite the fact that major efforts have been carried out on both observational and theoretical grounds in recent years, our knowledge of AGB stars is still deficient due to uncertainties related to mass loss, convection, mixing, dredge-up efficiencies, and the role of binary interaction processes. These uncertainties in our understanding of AGB stars directly propagate into the field of extragalactic astronomy, where they affect critically the interpretation of galaxy properties, e.g. stellar masses, ages, and the chemical evolution. The complexity of the objects also makes it difficult for individual researchers to master all aspects of their role as galaxy inhabitants, a problem that the proposed symposium aims to illuminate and overcome.

New and upcoming major observational facilities like ALMA, Gaia, JWST, LSST, SKA, and the ELTs will provide exciting opportunities to tackle these challenges from the observational side, stretching from the detailed study of individual objects that are spatially resolved to AGB populations in distant galaxies. At the same time, thanks to high-performance computing, 3D modelling of stellar interiors is starting to become feasible, propelling us toward a better understanding of the uncertainties related to the physics of AGB stars. This makes it particularly important to outline a strategic programme of combined theoretical and observational activities at this time.

In order to cover the large breadth of the symposium it is divided into nine themes, each one covered by invited talks, oral contributions, and posters. The themes are:

- Stellar structure and evolution to, on, and past the AGB
- Nucleosynthesis, mixing and rotation
- Pulsation, dynamical atmospheres and dust formation
- Circumstellar envelopes of AGB stars and their progeny, planetary nebulae
- Binarity, planets and disks
- AGB stars in the cosmic matter cycle
- Resolved and unresolved AGB populations in stellar systems
- Galaxy evolution, including the first AGB stars.

There will also be two plenary talks, one on nucleosynthesis and one on new and future observational perspectives. These will be centred on AGB stars, but also give a broader perspective of interest for research on stars and galaxies in general.

We wish you all a very constructive and pleasant four working days here.

Hans Olofsson, Franz Kerschbaum, and Paola Marigo, co-chairs SOC
Vienna, August 20, 2018

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In memoriam Thomas Posch (1974–2019)

The Department of Astrophysics of the University of Vienna and the Scientific Organizing Committee of IAU S343 mourns the loss of Thomas Posch, who passed away on the 4th of April 2019 after a long and difficult period of illness. Last year Thomas contributed in various forms at the 30th General Assembly of the International Union and until as recently as January this year he was still supervising students and holding tours of his home institute.

Thomas Posch was born on the 20th of February 1974 in Graz, Austria to Hildegard and Siegfried Posch. Between 1980 and 1984 he attended the primary school Volksschule Graben in the third district of Graz. He continued his education at the Bundesgymnasium Carnerigasse, where he chose to matriculate in the natural sciences branch of study. He graduated from the Gymnasium on the 1st of July 1992 with a high distinction. During his time at school he was the winner of the "Astronomy in Space" essay competition held by the European Space Agency (ESA). The following trips to the ESA/ESTEC institute in Noordwijk, the Netherlands and the Headquarters of the European Southern Observatory in Garching, Germany left a lasting impression on him. The 1990 Solar eclipse, which he viewed from Jansuu in southern Finland, also helped encourage his enthusiasm for astronomy and space research. It should also be mentioned that Thomas received the Bronze Medal at the 1991 Austrian Physics Olympics.

Thomas began his university education in 1992 in Graz by starting degrees in physics and astronomy. He spent an ERASMUS year at the Free University in Berlin, where he studied Physics and Philosophy. Upon returning to Austria, he moved to the University of Vienna, where he wrote his diploma thesis on the topic of "Circumstellar dust and the infrared-spectra of pulsating red giants" ("Zirkumstellarer Staub und die Infrarot-Spektren pulsierender Roter Riesen") under the supervision of Prof. Hans Michael Maitzen. He celebrated his graduation on the 9th of February 1999. Alongside taking part in many summer schools, Thomas visited the laboratory at the Department of Astrophysics at the University of Jena, Germany. This visit would prove to be of great importance for his future work in astrominerology.

His second great academic love, philosophy, and in particular the philosophy of nature, was the central topic of his next university endeavor between 1999 and 2002. Under the supervision of Prof. Friedrich Grimmlinger (Vienna) and Prof. Renate Wahsner (Berlin) Thomas delivered his dissertation titled "The Mechanics of Heat in the Jena System Design by Hegel from 1805/06" ("Die Mechanik der Wärme in Hegels Jenaer Systementwurf von 1805/06") which commented on the background to the development of the theories of thermodynamics between 1620 and 1840.

Thanks to a competitive research scholarship from the Austrian Academy of Science Thomas was able to submit his doctoral dissertation titled "Astromineralogy of Circumstellar Oxide Dust" in 2005. His supervisors for this project were Prof. Franz Kerschbaum (Vienna) und Prof. Thomas Henning (Heidelberg). The scientific core of the dissertation was the comparison of the signatures of cosmic dust, as observed by the ISO space telescope, with terrestrial analogues. The results of which were published in several international journals. His work has inspired several students and has fully established the field of astrominerology in Vienna.

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As part of his military service in 2005, Thomas Posch conducted the first systematic study of the night sky brightness in Austria. This was an important base for his future work towards the preservation of the night sky.

After having worked as a guest scientist in Jena and after receiving a scholarship from the Max-Planck-Society, Thomas took up a position as Staff Scientist at the Department of Astronomy (now Astrophysics) at the University of Vienna in April 2006, almost exactly 13 years ago. Alongside his scientific endeavors, he also took on various responsibilities regarding the institute's library and historically important archives, as well as being engaged with public outreach activities. Of these his most noteworthy contributions include the expansion of the collection related to Maximilian Hell ("Schausammlung Maximilian Hell"), the screening and analysis of historical relevant archive material, and the supervision and coordination of large events such as the International Year of Astronomy 2009.

In 2011 years of fruitful astronomical research culminated in the comprehensive habilitation dissertation titled "Studies in Astromineralogy and Stellar Mass Loss", which allowed Thomas to teach at the level of docent. He distinguished himself both through his teaching and through his supervision of students. He brought together knowledge from many fields of research ranging from star formation and evolution, mineralogy, life, as well as historical topics and didactic methods in the natural sciences. A natural extension to his university courses were his vast, comprehensive, and popular public lectures, which made him into a well-known public educator both within and outside Austria. This was surely helped by his many contributions to radio and television programmes.

His national and international reputation led to a series of important roles in professional societies, as well as honors and accolades. Several positions worth mentioning include: chairman of the advisory board for "transdisciplinary science" at the Guardini foundation (since 2013), chairman of the working group for historical astronomy of the Astronomical Society (since 2014), contributing member of the ÖNORM committee on Light-Emission (between 2008 and 2012). In 2014 Thomas Posch also received the Galileo Award from the International Dark Sky Association.

During the last three years, even as the progressing illness curtailed his abilities, Thomas remained faithful to all areas of his work. He published papers, held lectures, taught, organized, and coordinated until the very end. The General Assembly of the International Astronomical Union held in the summer of 2018 in Vienna, with its multifaceted and diverse conference formats, was the last major event where Thomas played a leading role. Here he also chaired the annual meeting of the working group for the history of astronomy. As late as January 2019 Thomas was still supervising students and holding lectures. He passed away on the 4th of April 2019.

To honour the work of Thomas Posch the International Astronomical Union decided to name the main belt asteroid 2008 TP9 (328432) Thomasposch.

The following paragraphs are devoted to the major achievements from each of Thomas Posch's fields of research:

In the realms of astrophysics Thomas Posch concentrated mainly on astrominerology. His interest in explaining infrared emission bands from semi-periodic variable red giant stars as observed with the ISO satellite began during his time as a university student. Such bands are produced by mineral dust particles, primarily refractory oxides and silicates, condensing in stellar outflows. By working with Johann Dorschner and Thomas Henning at the Jena astrophysical laboratory Thomas was able to compare these observations with

data from laboratory measurements of analogous terrestrial material, thereby explaining the nature of cosmic dust. Furthermore his collaboration with Johann Dorschner, Dirk Fabian, Harald Mutschke, Cornelia Jäger and Gabriele Born and their work on Aluminium oxides (Corundum, Spinel, Hibonite), Iron oxides, and Titanium oxides led to several important publications. In particular, the identifications of aluminium oxides with the stellar 13 μm band and of magnesium/iron oxides with the 19.5 μm band will remain related to his name for all time.

A related and also very important topic in Thomas Posch's work was the absorptivity of minerals in the wavelength range of stellar radiation. Again in the laboratory in Jena, Thomas investigated the influence which doping ions like Chromium and Iron had on the absorption spectrum of spinel. He was the first to calculate, using laboratory data, their temperature in the radiation field of a star. Together with Simon Zeidler he wrote a highly cited paper which also included absorption spectra of titanium oxides and silicates. Thomas demonstrated the need for, and the importance of, dust observations during the preparation of the far-infrared PACS spectrograph onboard the Herschel-Mission. Afterwards he provided comparative datasets for dust spectra in the corresponding spectral range. This included measurements on carbonates for temperatures down to 10 K in the Jena laboratory, and a spectroscopic study of hydrous silicates, which can provide an important hint to liquid water in planetary systems (with H. Mutschke). During the last years, he published together with S. Zeidler temperature-dependent optical constants of oxides and silicates, ultimately putting the assignment of aluminium oxide to the 13μm band on solid grounds.

From early on Thomas Posch was not only interested in the natural sciences, but rather also in the philosophical and epistemological questions connected to science. Quite often he would begin by using the historical approach. An example of this concerns the history of the Vienna institute during the Third Reich, which was then led by Bruno Thüring. Thüring was a long standing critic of Einstein and confidant of Wilhelm Führer. Führer, who was originally an astronomer, was Obersturmführer of the Waffen-SS and became a leading bureaucrat in the ministry of science of the Third Reich. Based on their preserved correspondence and published records, Thomas was able to build up a detailed picture of the times and also validate Thürings misuse of Hugo Dinglers philosophy.

The rare book collection of the University Observatory in Vienna dates back to the time of Peuerbach and Regiomontanus. Thomas Posch re-examined key works in this collection with an emphasis towards connections to Austria (e.g. by Kepler) and to astronomical phenomena. With these insights he composed literary works, and even theatrical pieces. His dramolett: "Kepler, Galilei and the Telescope" appropriately presented during the International Year of Astronomy 2009, told the story of the academic battle in the 17th century regarding the new emerging world view, the role that observations played, and the vanity of many of the central figures. Furthermore, his edition of Littrow's text detailing the history of astronomy ("Littrows Geschichte der Astronomie", together with Günter Bräuhofer and Karin Lackner, 2016) and the texts about Maximilian Hell's trip to Nordland based on excerpts from his on the diaries at the institute, would not have been possible without his extensive work with the archives.

Thomas Posch's research in philosophy also covered a wide range of topics. His lifelong interest in Hegel began during the time he wrote his dissertation under Friedrich Grimmlinger (Wien) and Renate Wahsner (Berlin). As part of the Society of System Philosophy (Gesellschaft für Systemphilosophie), Thomas was able to fruitfully introduce Hegel's thoughts into modern day philosophical and scientific discourse. His goal was to consistently achieve the problematization of the reductionistical point of view. By using

this perspective he was able to foster the conversation between the natural sciences and theology. This was manifest in his contributions to present-day debates, in the already mentioned historical studies, and especially in his Monograph about Johannes Kepler ("Johannes Kepler. Die Entdeckung der Weltharmonie", WBG, 2017). Furthermore, he never shied away from questioning his supremely personal connection to faith and spirituality, especially given his occupation as a scientist. Given his background it is worth mentioning his well-grounded and thorough criticism of astrology, which he delivered through essays and lectures. Throughout his whole life it was important to Thomas to clearly separate science from pseudoscience and esotericism.

During the 1997 IAU General assembly in Kyoto, Japan, the problem of the rapid loss of dark night skies due to artificial light sources was raised. This motivated Franz Kerschbaum and soon thereafter also Thomas Posch to systematically quantify, and concurrently raise awareness of this ever growing problem. Simple and generally available measurement techniques needed to be developed. During Thomas's military service, he conducted the first study of the night sky brightness in Austria. Since then Thomas has accompanied many projects to modernize communal lighting as consultant. His edited-book "Das Ende der Nacht. Die globale Lichtverschmutzung und ihre Folgen" ("The End of Night. Global light pollution and its consequences") was released in 2009 and is currently in its second edition. It is seen as standard literature on the subject in German speaking countries and beyond. Especially in the last years of his life, one of Thomas' greatest concerns was to spread the message of the importance of preserving a naturally dark sky to both the general population and the relevant authorities. He was a consultant during the construction of a light-measurement-network in Upper Austria between 2014 and 2016. He was also one of the authors of the "Austrian guide to outdoor lighting" ("Österreichischer Leitfaden für Außenbeleuchtung"), which was signed by many provincial environment councilors. The data and results collected from the network were able to show which areas in the state of Upper Austria could still be classed as "Dark Sky Sites". Such places are eligible for an official certification as such. Through his role as a co-organizer of the Upper Austrian environment congress 2018 in Linz, Thomas was able to present this project to the public. It was enthusiastically received. Such protected area will serve as a role model for other regions in Austria. The implementation of such areas as well as passing on his knowledge to his doctoral student, Stefan Wallner, were top priorities for him until the very end. His work and the way he went about it will without a doubt be recognized well into the future.

Thomas's talent and desire to share the fascinating field of astronomy with the general public was already apparent during his time as a student. This was evident not only in his series of published popular scientific works, but also in his engagement with the public outreach activities at the university observatory in Vienna. An example of this engagement was the star counting initiative "How many stars can we still see", organized together with the Kuffner Observatory Association as part of "Science Week 2001". This initiative was the first Austrian-wide attempt to quantitatively determine the brightness of the night sky. His wide and varied knowledge and range of interests, as well as his welcoming and calm personality, meant that Thomas Posch was predestined for working with the wider public. A role which he gladly took on in 2006 as part of his position as staff scientist. Answering questions, contributing to popular science magazines and media outlets, reporting on the newest scientific results and insights (e.g. the yearly astronomical review on science.orf.at) were all part of Thomas's everyday activities.

One activity which Thomas Posch took on with great enthusiasm and competence, were the tours of the institute, and especially those to the large refractor telescope. During

his time at the institute he gave more than 700 tours to guests of all ages and from all walks of life, from Austria and abroad. Given his broad knowledge of astronomy and astrophysics, as well as history and philosophy, these tours were a very special experience. Furthermore his excellent knowledge of foreign languages meant that he was able to hold tours not only in German, but in English, French, and Italian. His tours were always well received.

Naturally, Thomas also always played an important role in the organization of larger events, such as the "long night of research" ("Lange Nacht der Forschung") or the Children's University (Kinderuni). He also often took on the role of main organizer, e.g. for the Year of Astronomy 2009. His last great challenge was most certainly the 30th General Assembly of the IAU in Vienna in 2018, where he took on a series of official roles. Most notably those of the media spokesperson, and as a member of the editorial team for the daily conference newsletter. He was able to pass his enthusiasm, enjoyment, and wealth of experience in, and for, public outreach on to his students in many different ways, as well as always maintaining an emphasis on quality. A late example of this was his very active involvement with the course associated with the institute's mobile planetarium. Thomas Posch continued to maintain close contact to, and valued the contributions of, amateur astronomers as their contributions to public outreach was, and still is, invaluable. He also never stopped enjoying looking through his own not-so-small telescope.

Thomas's works as an author should also not be forgotten. His various pieces of short prose and somewhat more strongly condensed lyrical (if rhymeless) verses accompanied him throughout his life. The first collection of these works appeared in the Viennese "Edition Doppelpunkt" in 2001 with the title "Miniaturen. Ein bißchen Literatur" ("Miniatures - A little bit of Literature"). In the meantime he has written enough new texts that a second volume could be filled. In his pieces of Prose, Thomas used short stories to critically, yet amusingly, illuminate typical behaviours of modern-day humans. His lyrical verses described his personal, and not seldomly painful experiences in simple, yet deep and meaningful sentences. The literary styles in both verse and prose which he found are quite clearly his own creation, and very much worthy of attention and recognition.

An obituary by Franz Kerschbaum, with contributions from Josef Hron, Cornelia Jäger, Harald Mutschke, Johann Schelkshorn, Wilhelm Schwabe and Stefan Wallner. Translated into English by Kieran Leschinski.

Vienna, April 2019

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