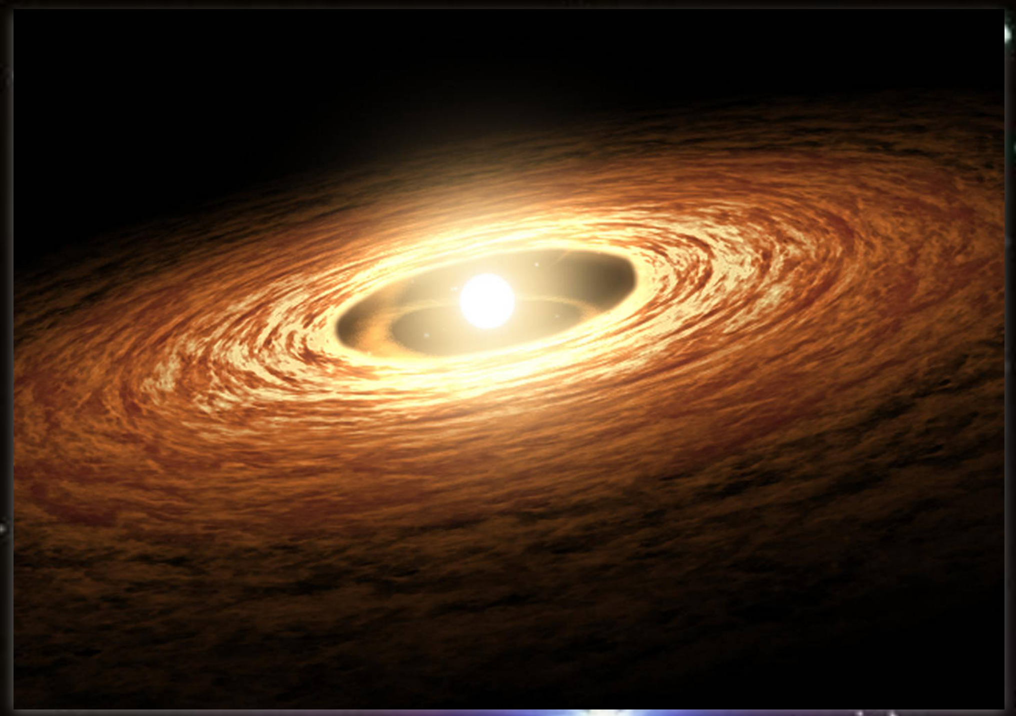
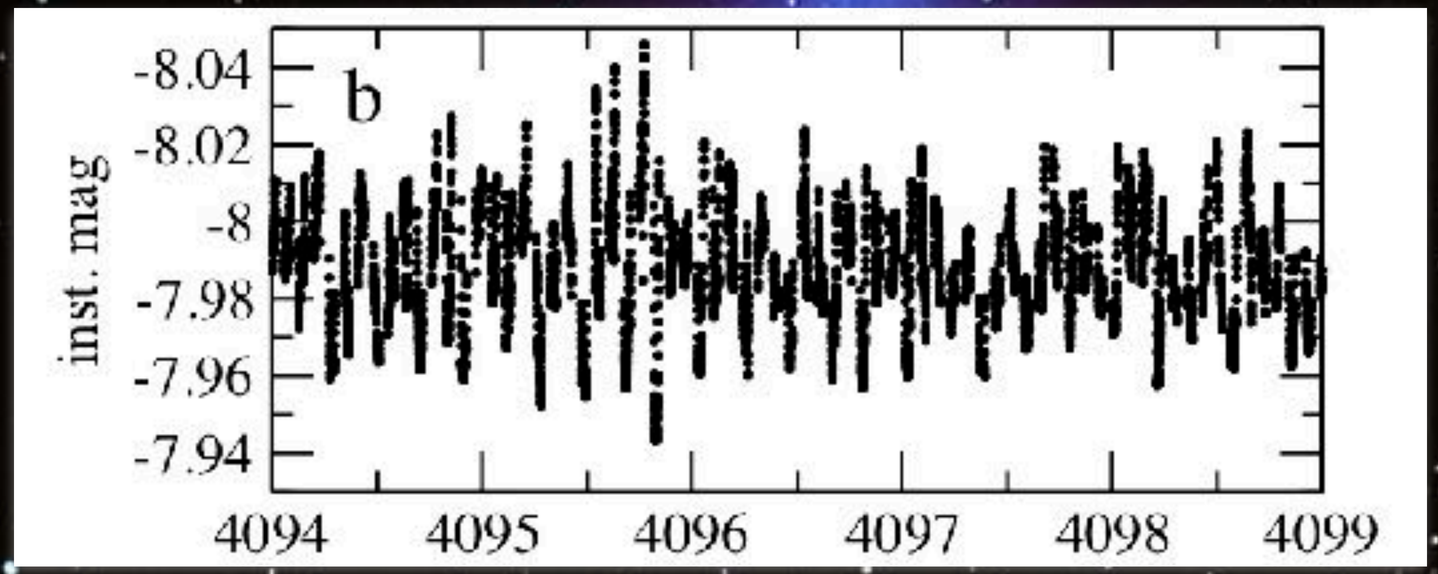
universität innsbruck

Arbeitsgruppe

Sternentwicklung Und Asteroseismologie





Konstanze Zwintz

Sternentwicklung & Asteroseismologie

Das Leben der Sterne (Geburt bis Tod)

Sternentwicklung & Asteroseismologie

Das Leben der Sterne (Geburt bis Tod)

Lehre der Sternschwingungen

Sternentwicklung & Asteroseismologie

↓ ↓

Das Leben der Sterne (Geburt bis Tod)

Lehre der Sternschwingungen

Bestehendes Konzept der Entwicklung von Sternen: viele offene Fragen

***Ziel:* Verbesserung dieses Konzepts**

***Schwerpunkt:* Sterne in ihrer Kindheit und Jugend**

DIE ENTWICKLUNG VON STERNEN

Protostars

Image sources: NASA, ESA, K. Luhman and T. Esplin (Pennsylvania State University), et al., and ESO; NASA/ESA/HubbleHeritage; NAOJ; EHT Collab.; Kevin Gill Flickr (CC by 2.0); ESO/Kornmesser

DIE ENTWICKLUNG VON STERNEN

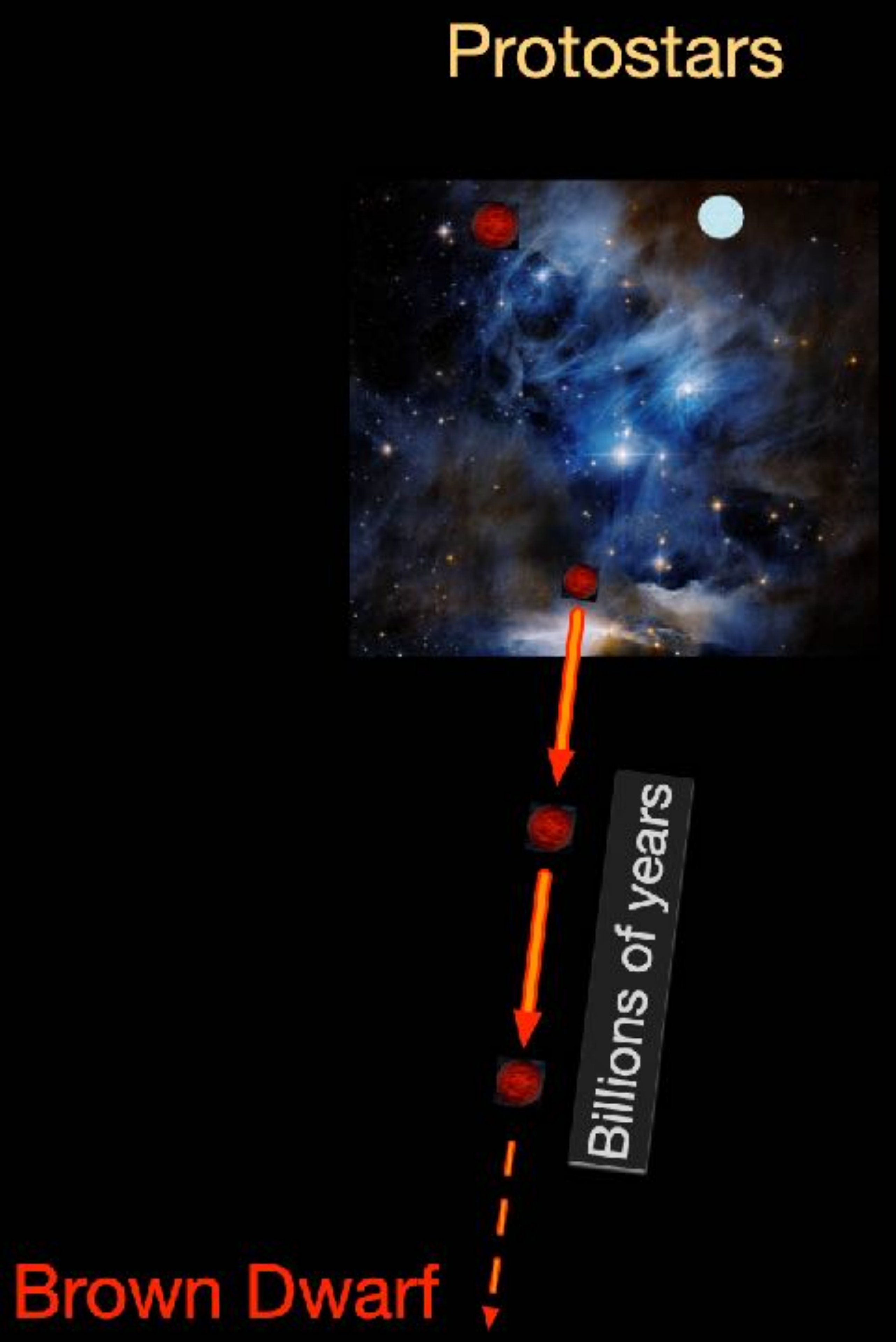
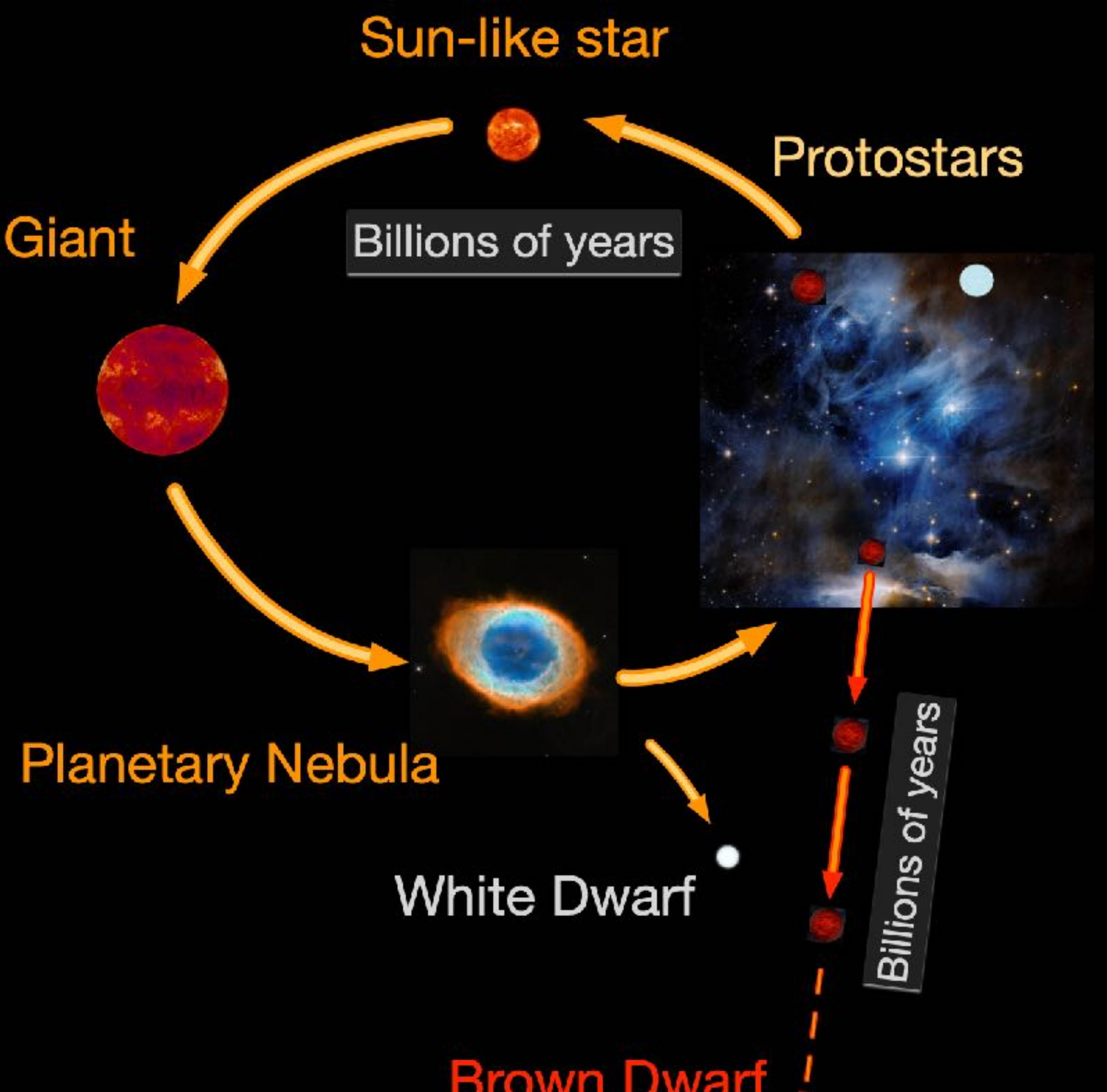
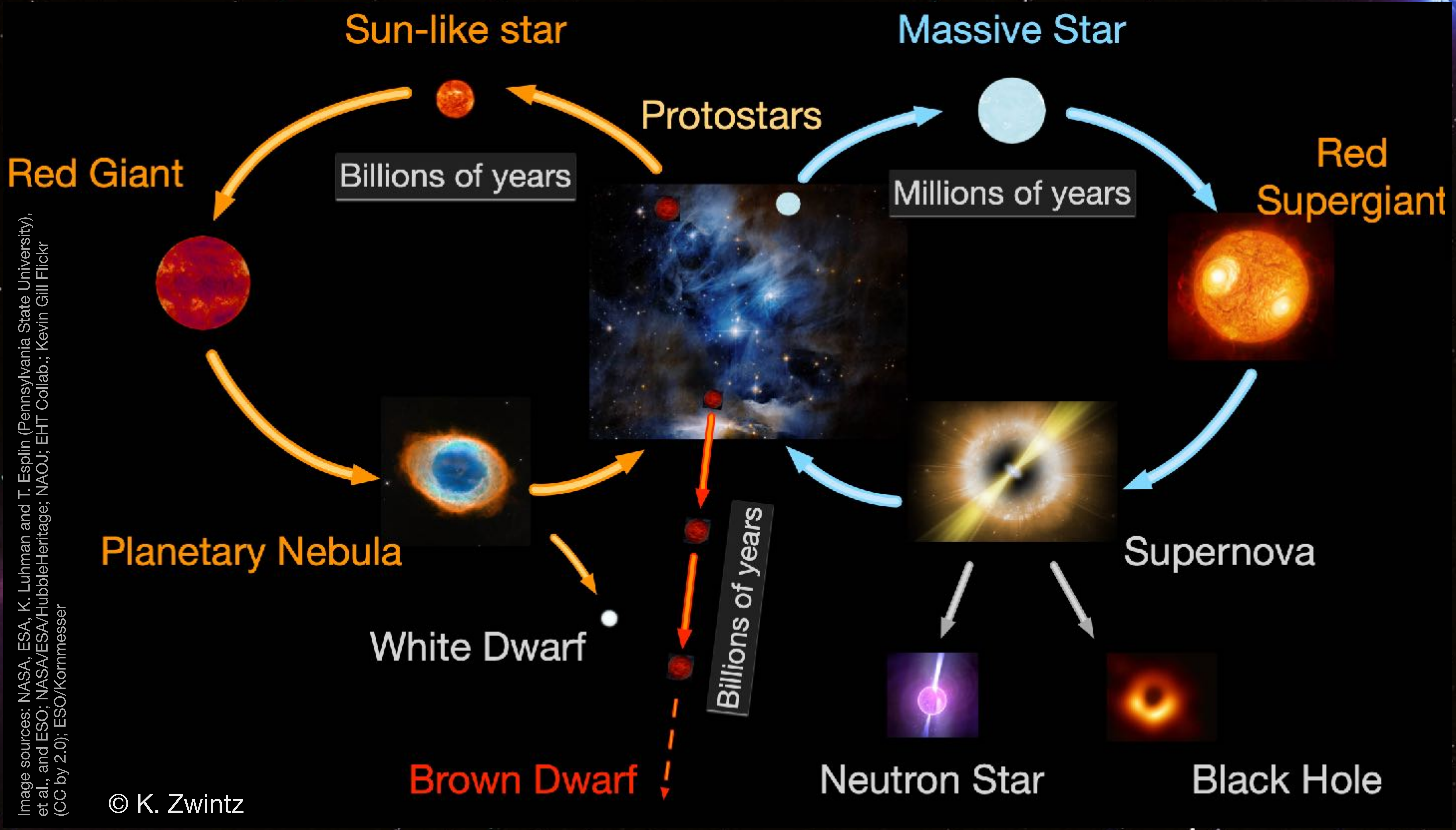


Image sources: NASA, ESA, K. Luhman and T. Esplin (Pennsylvania State University), et al., and ESO; NASA/ESA/HubbleHeritage; NAOJ; EHT Collab.; Kevin Gill Flickr (CC by 2.0); ESO/Kornmesser

Die Entwicklung von Sternen

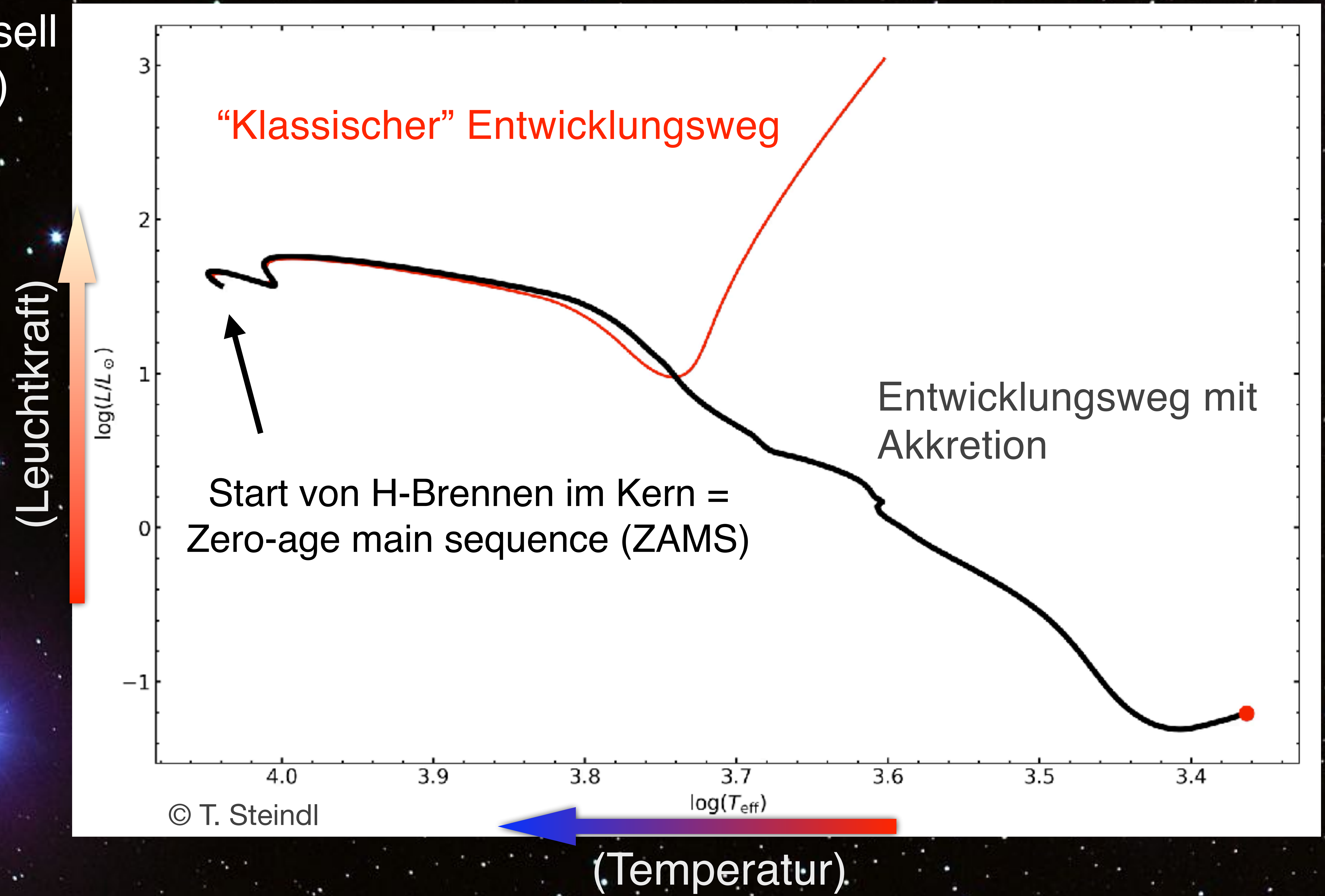


Die Entwicklung von Sternen

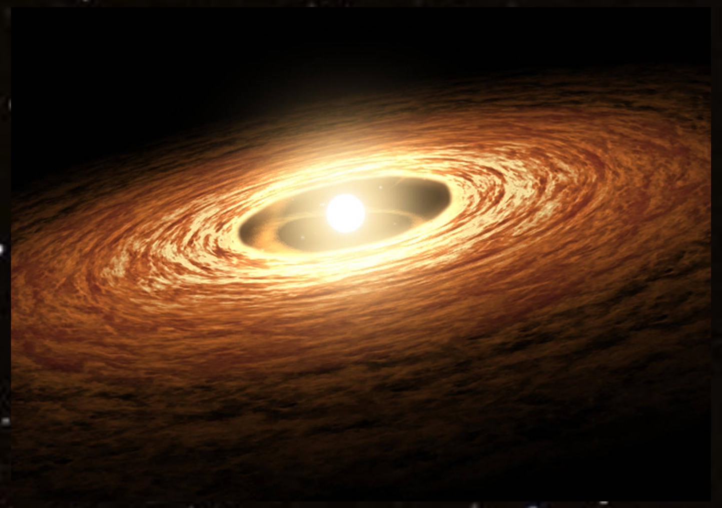


Kindheit & Jugend von Sternen

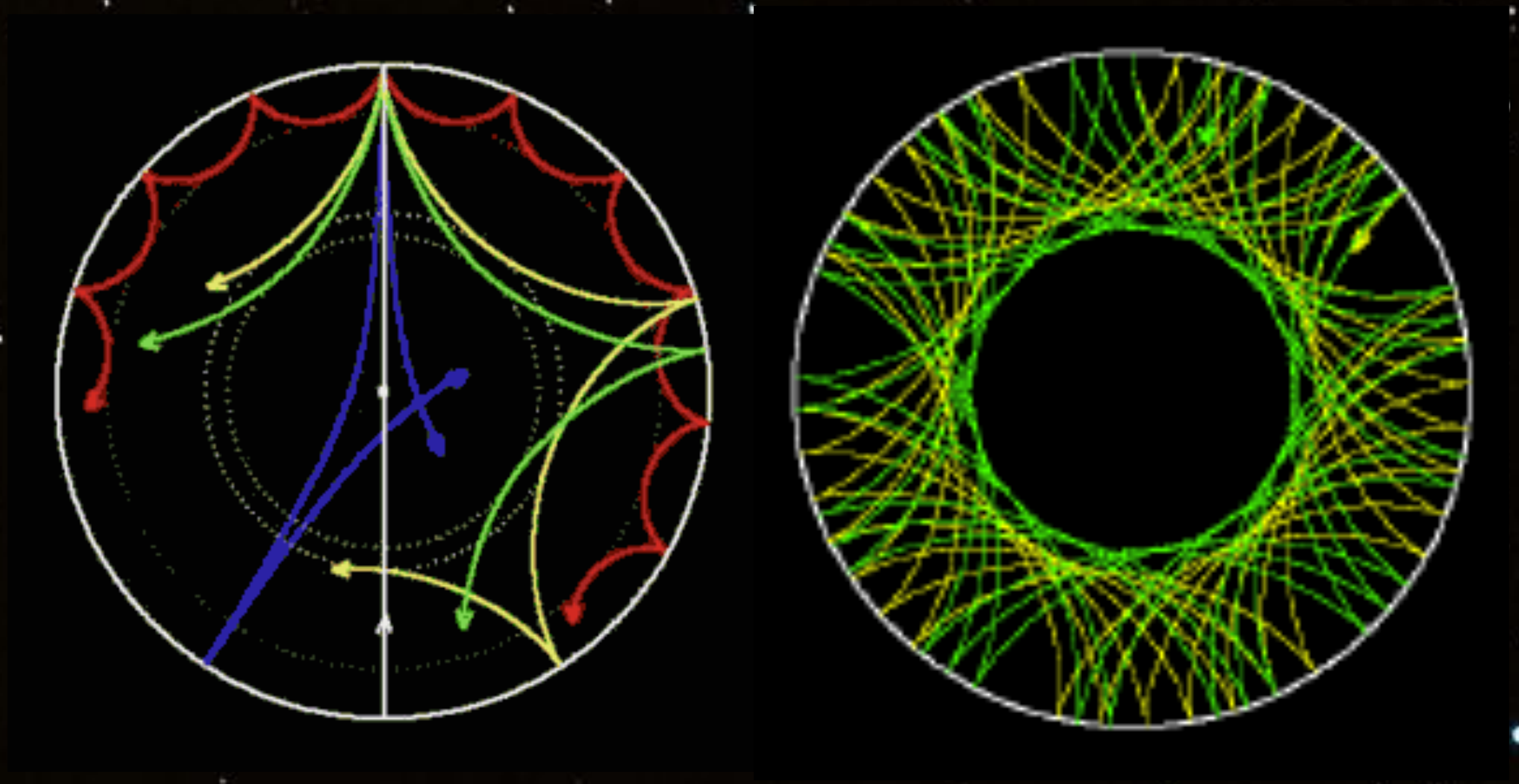
Hertzsprung-Russell Diagram (HRD)



Protostern eingebettet in Staub und Gas

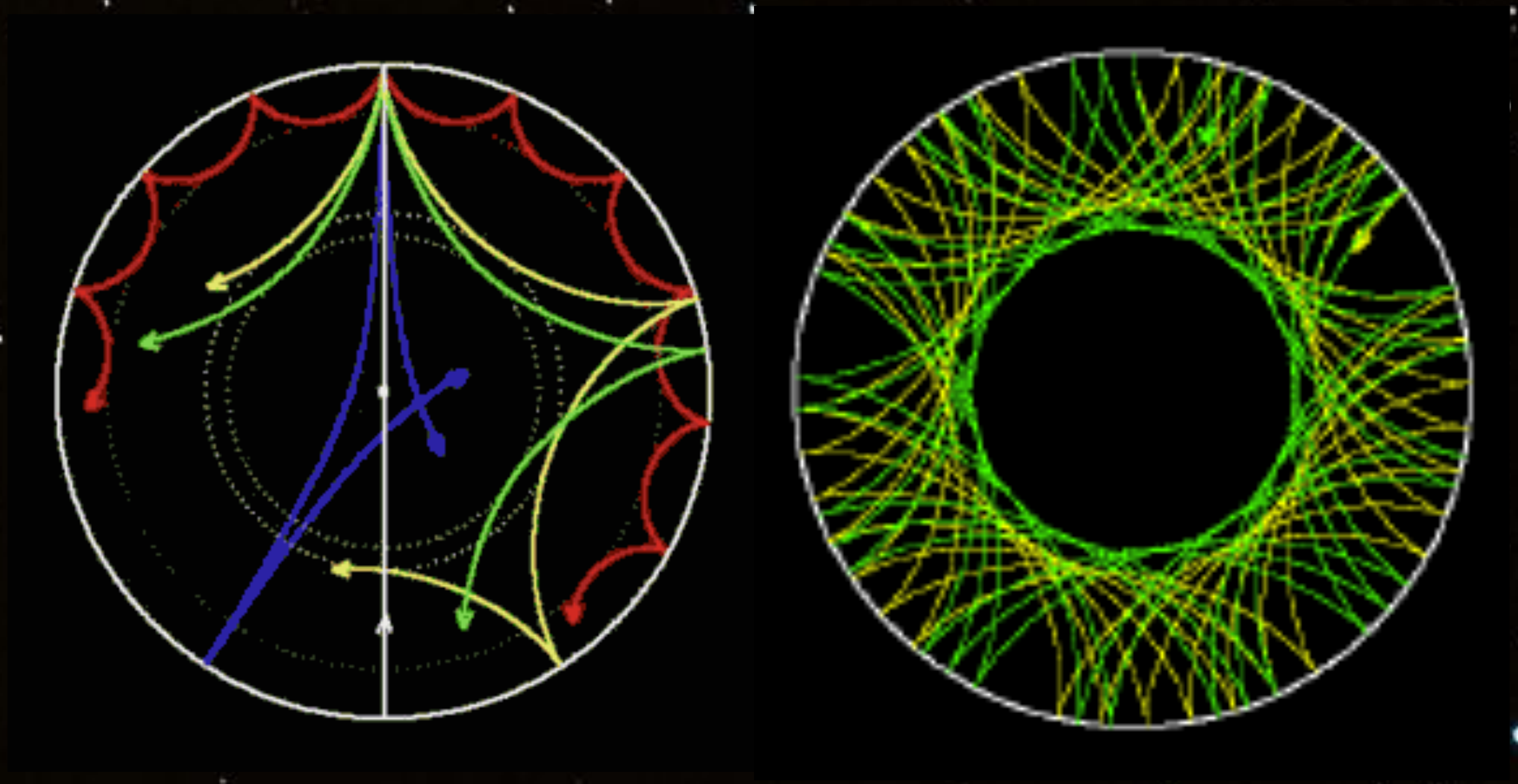


STERNSCHWINGUNGEN



$$\xi_{nlm}(r,\theta,\Phi,t) = \xi_{nl}(r)Y_{lm}(\theta,\Phi)e^{-i\omega_{nl}mt}$$

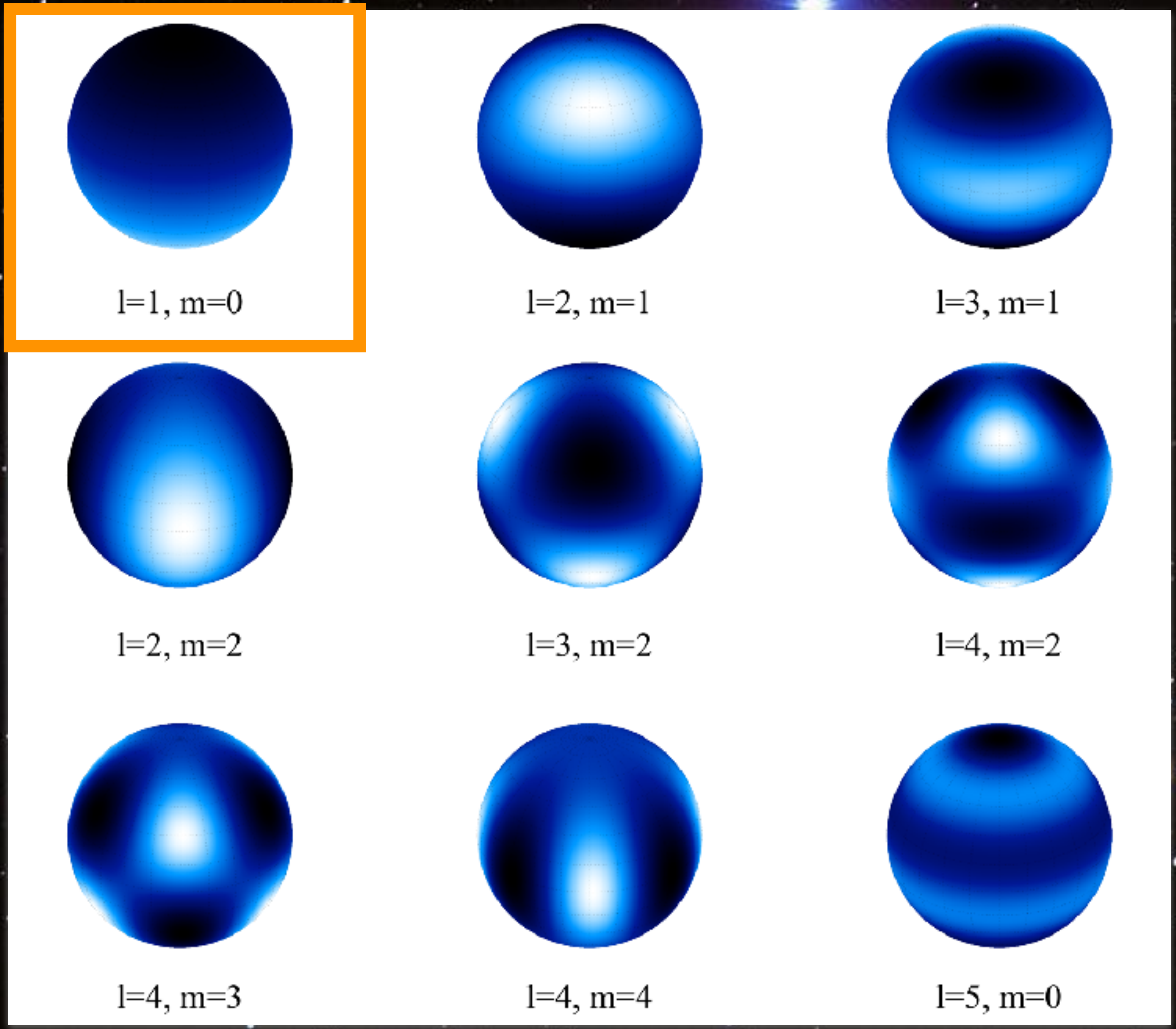
Sternschwingungen



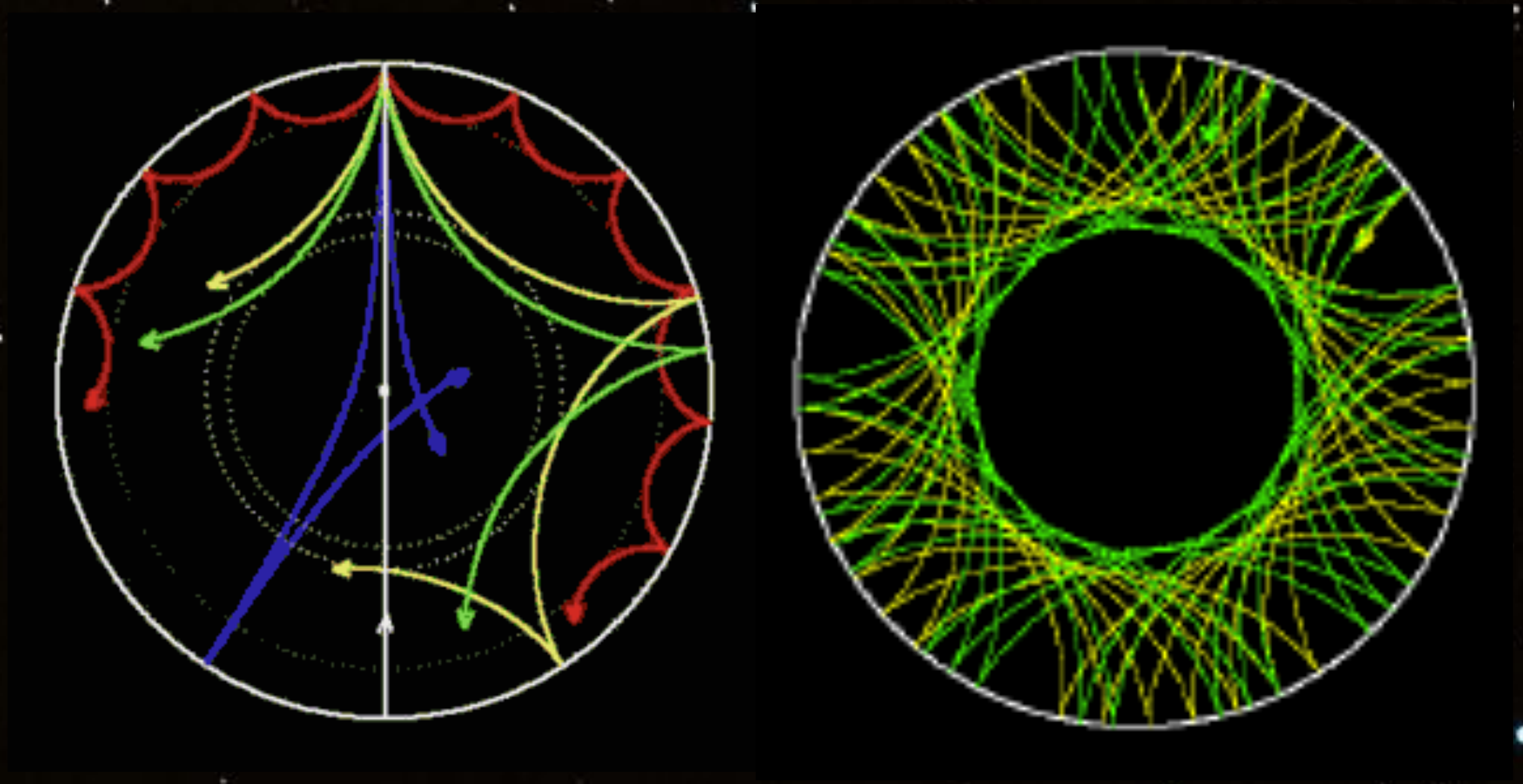
$$\xi_{nlm}(r,\theta,\Phi,t) = \xi_{nl}(r)Y_{lm}(\theta,\Phi)e^{-i\omega_{nl}mt}$$

radial

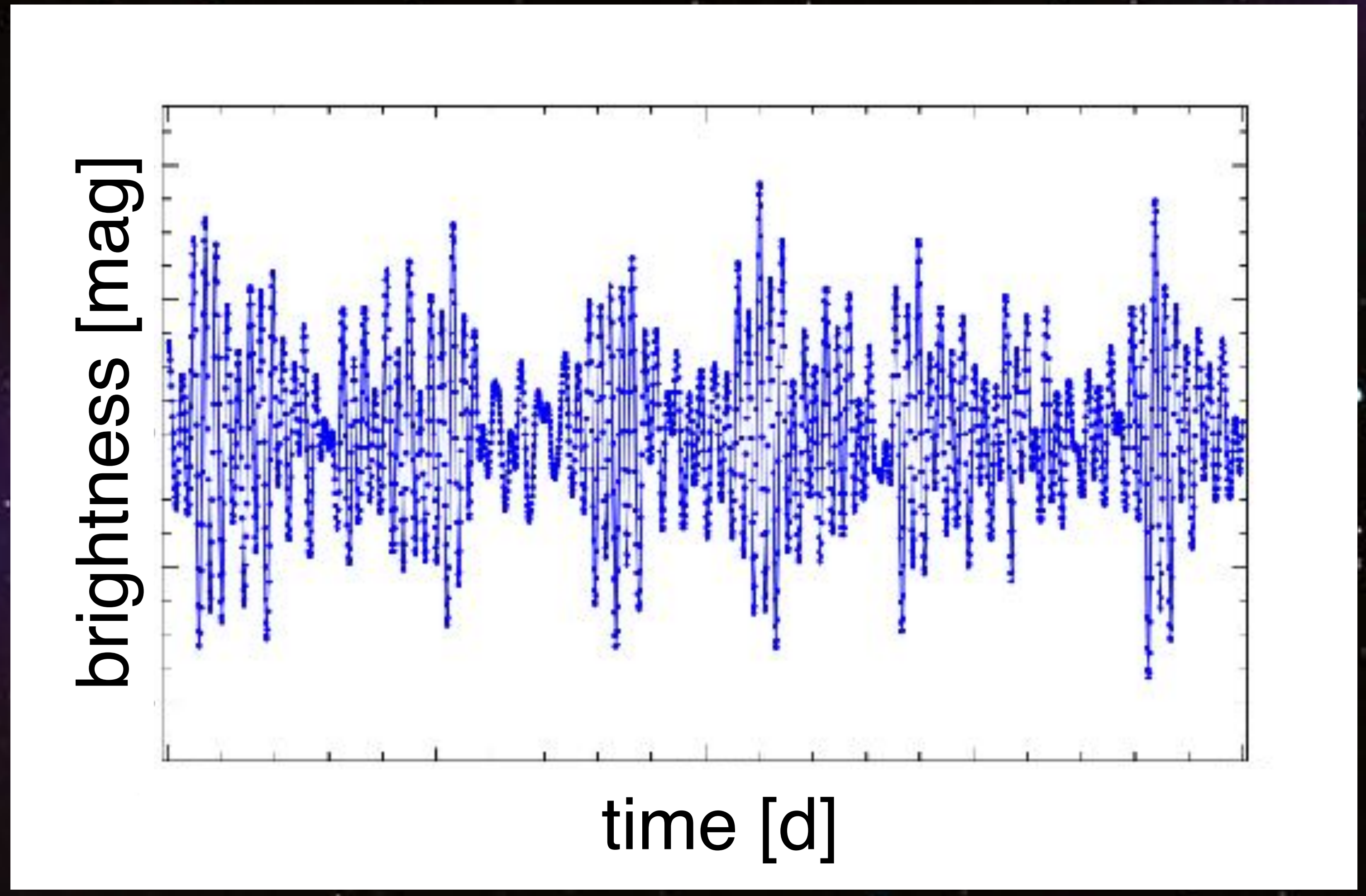
nicht-radial



STERNSCHWINGUNGEN

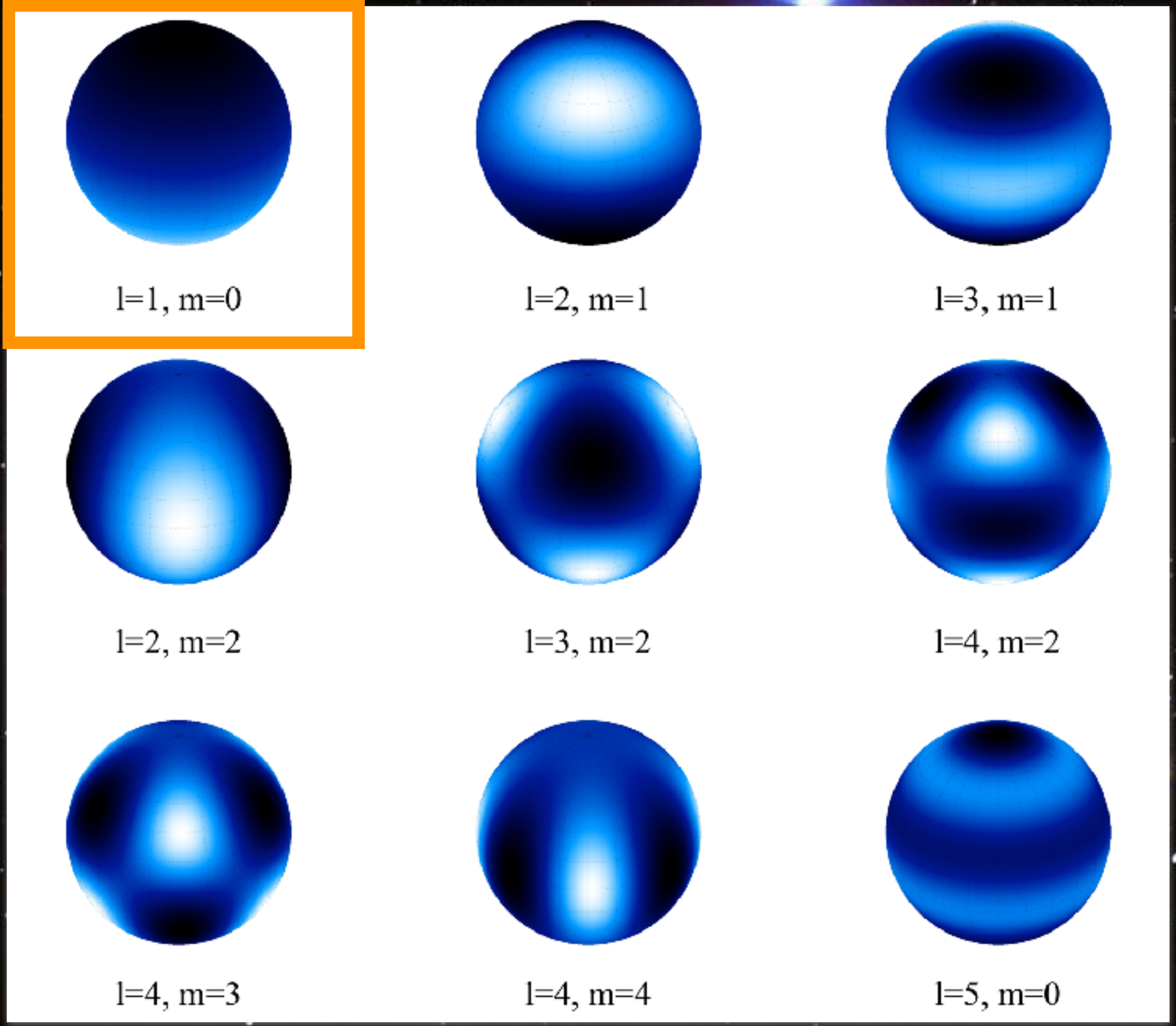


$$\xi_{nlm}(r,\theta,\Phi,t) = \xi_{nl}(r) Y_{lm}(\theta,\Phi) e^{-i\omega_{nl}mt}$$



radial

nicht-radial

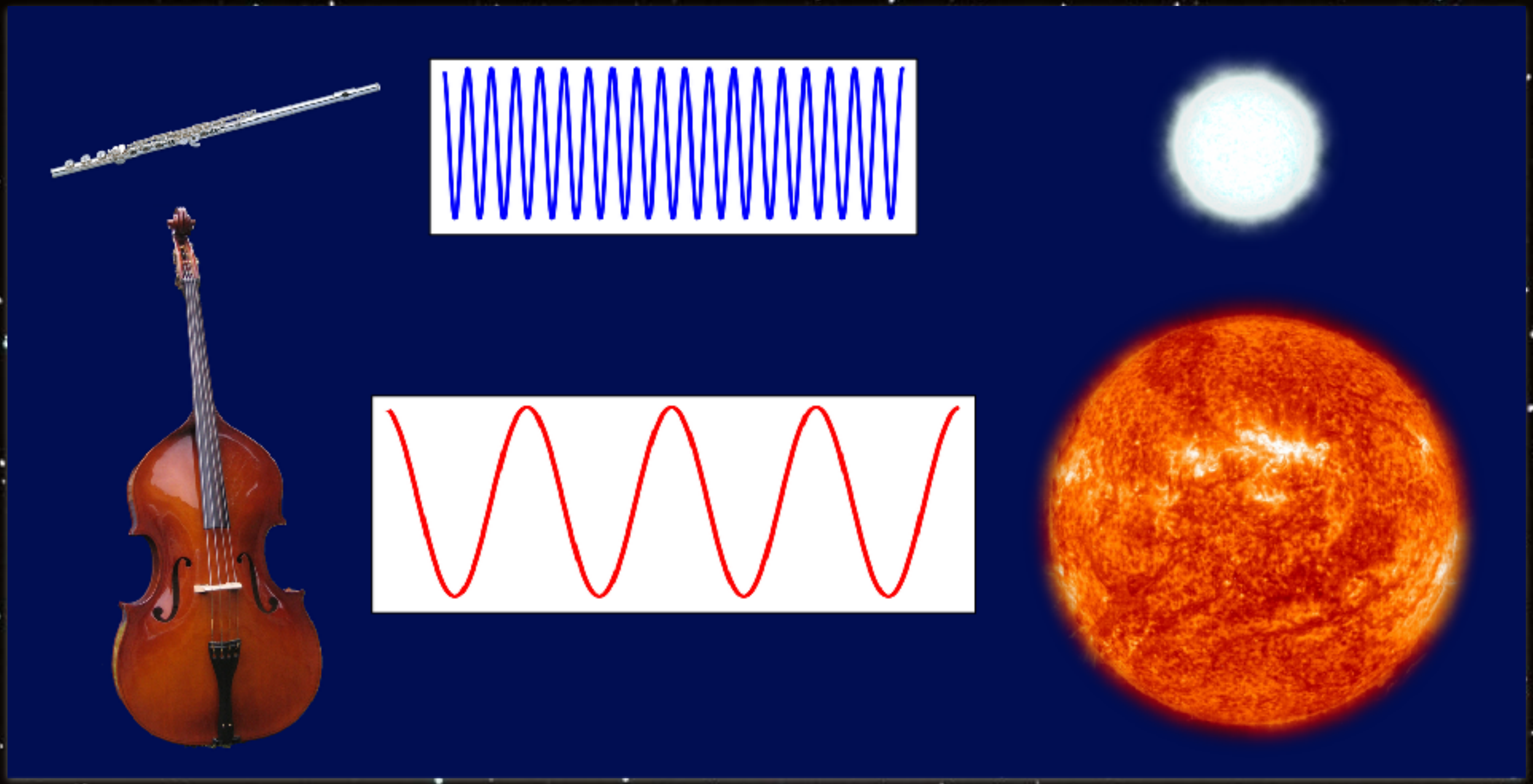


Messdaten von Satelliten

Sterne als Musikinstrumente

Hoher Ton

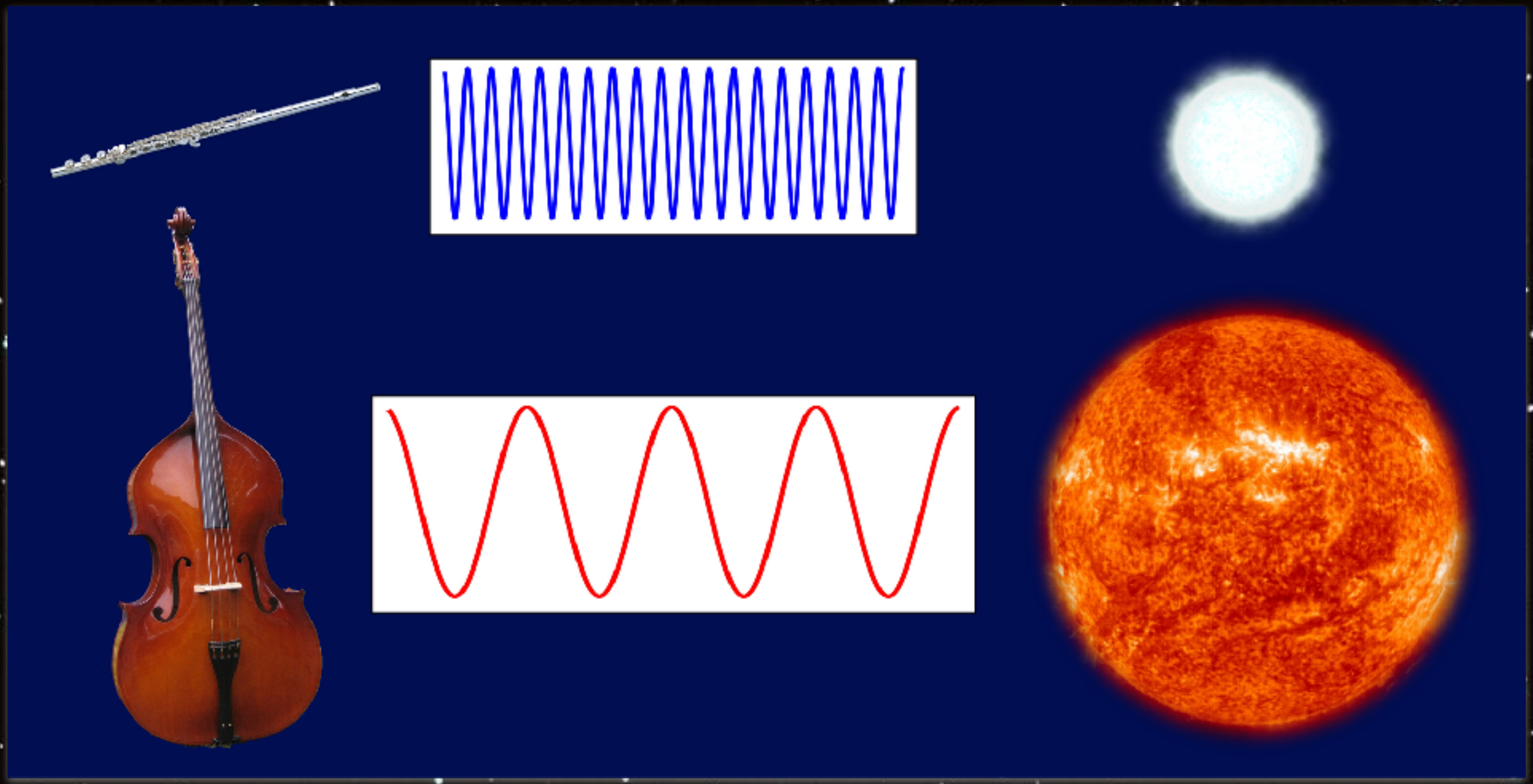
Tiefer Ton



Sterne als Musikinstrumente

Hoher Ton

Tiefer Ton



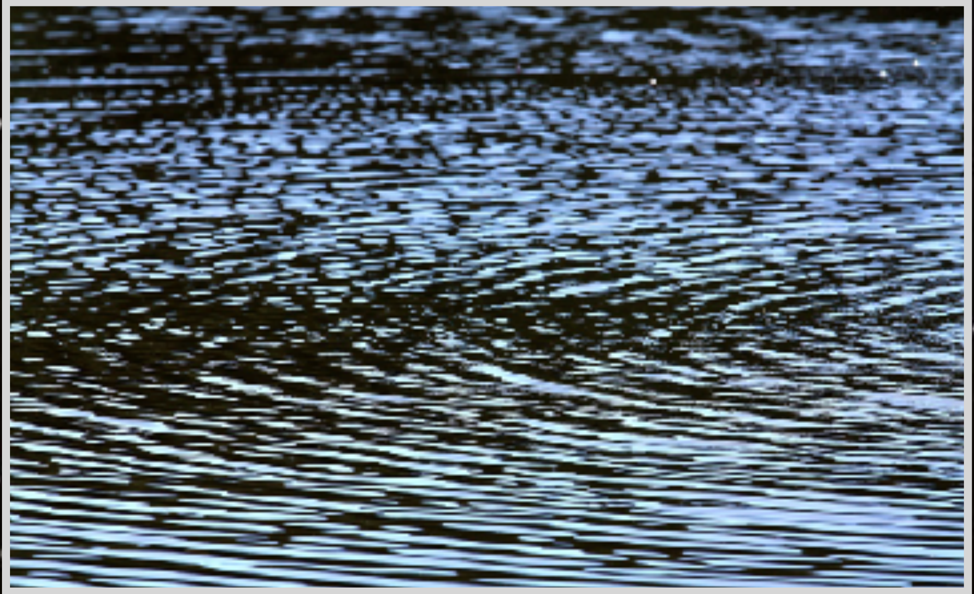
- Frequenz
- Amplitude
- Phase

→

- Art der Schwingung = das “Musikinstrument“
- Innerer Aufbau der Sterne (Dichte, Druck, Chemische Zusammensetzung, etc.)

PULSATIONEN: "GRAVITY MODES"

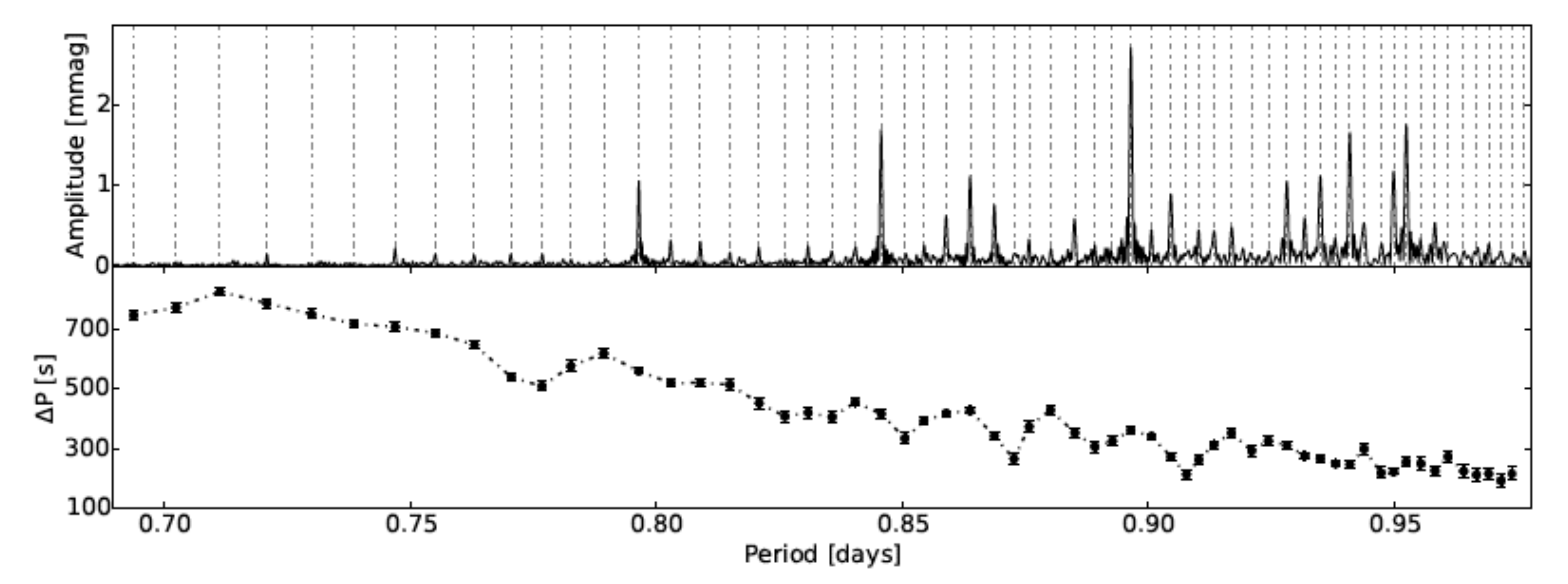
- **Anregung**: "Heat engine"-Mechanismus
- **Rücktreibende Kraft**: Auftrieb ➜ "gravity" (g)-Moden
- **Perioden**: 0,5 - 3 Tage
- ***Slowly Pulsating B stars***: 2 - 7 Sonnenmassen
  γ Doradus Sterne: 1,4 - 2,5 Sonnenmassen



Wasserwellen

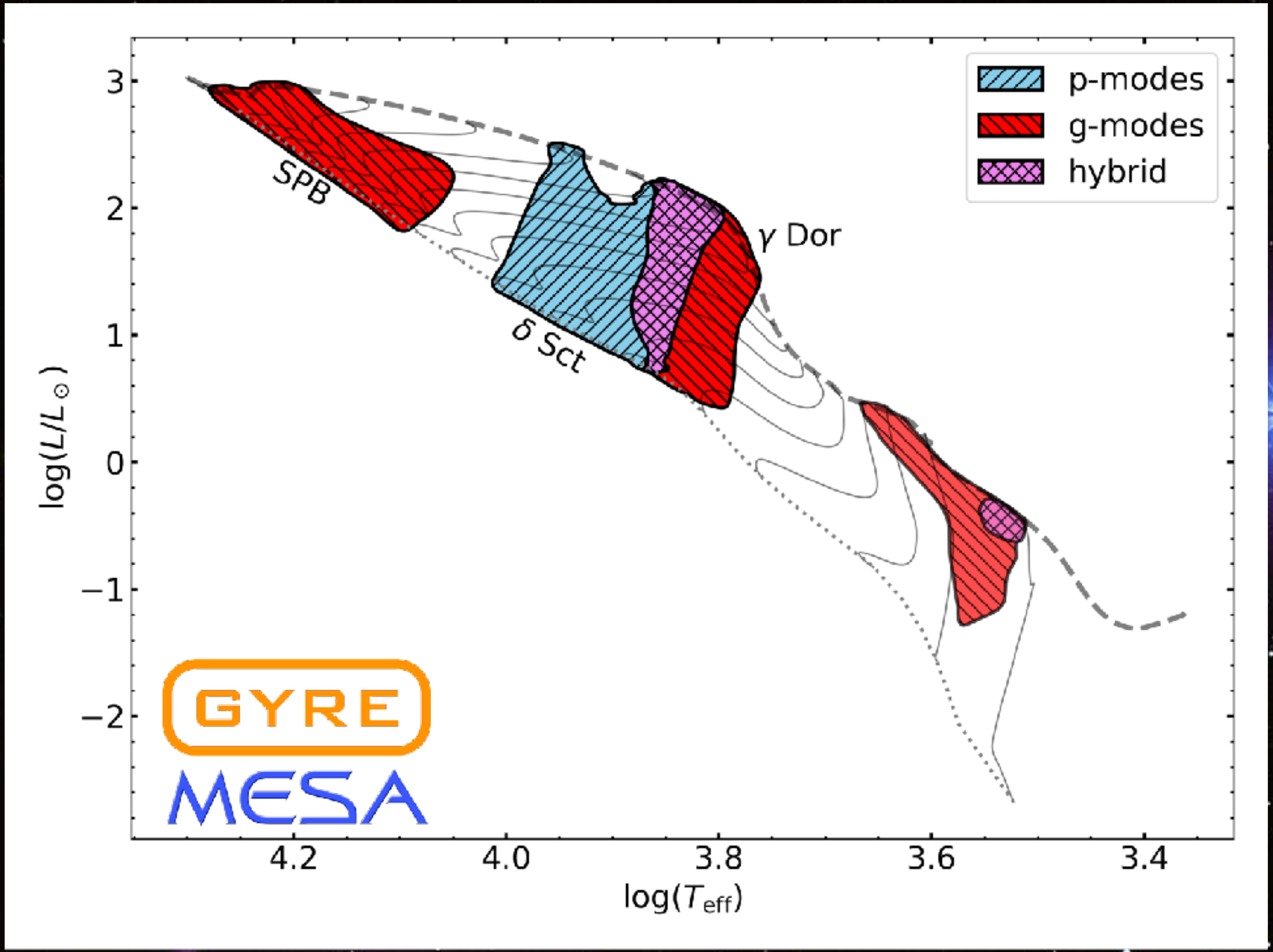
Beispiel:

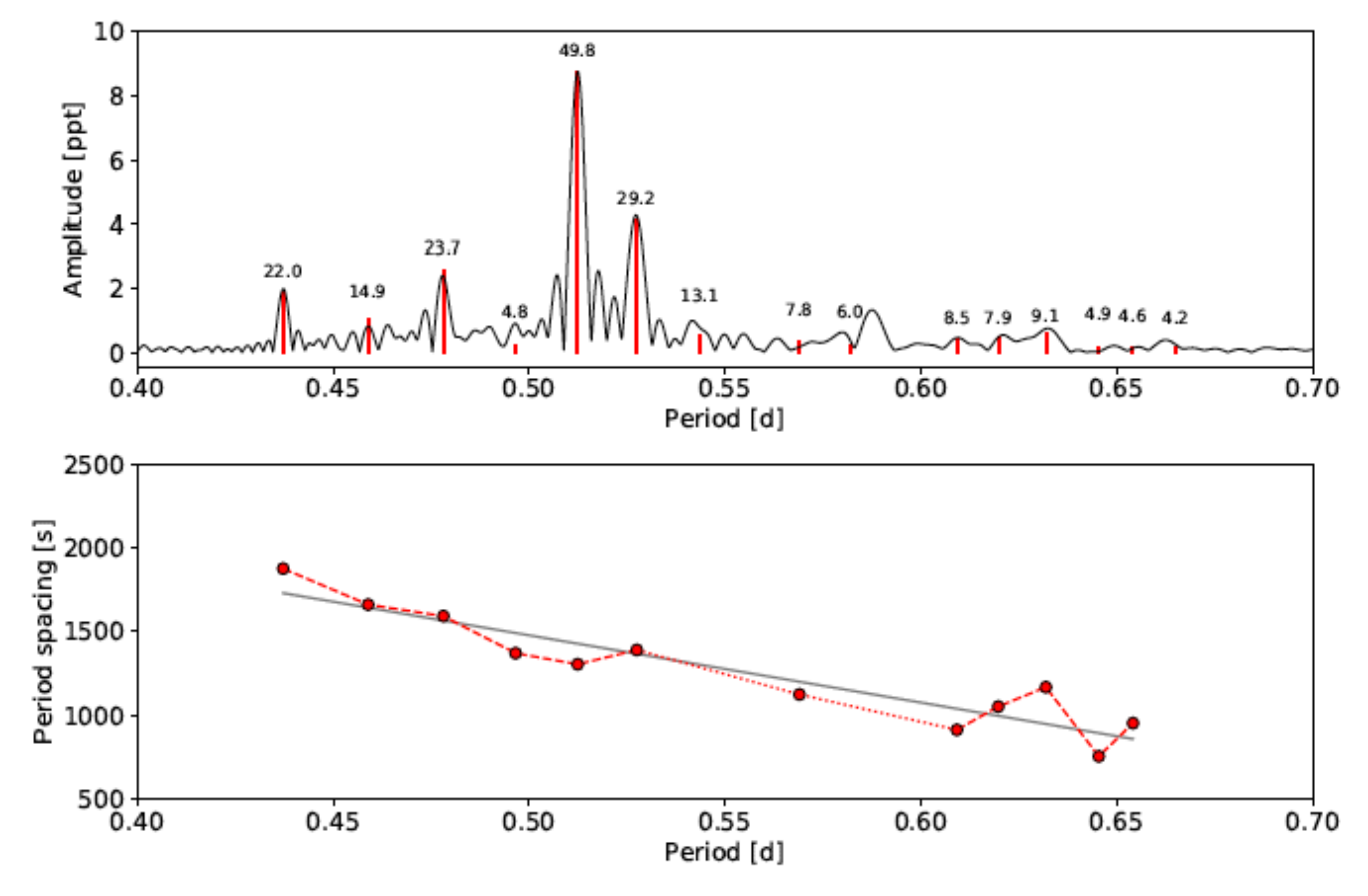
KIC 5708550



Van Reeth et al. (2014)

JUNGE STERNE & GRAVITY MODES





Regelmäßige Periodenabstände in einem jungen Slowly Pulsating B Stern

Bachelorarbeit

- Frequenzanalyse von jungen Sternen mit g-moden Pulsationen
  - Daten von Satellitenmissionen CoRoT, Kepler K2 und TESS
- Suche nach regelmäßigen Abständen in Periode
- Beschreibung der Lage im Hertzsprung-Russell Diagramm
- Interpretation der Periodenabstände in Zusammenhang mit entwickelteren Sternen auf der Hauptreihe und in Zusammenhang mit der Stärke der Rotation

Kontakt: Konstanze Zwintz
Viktor-Franz-Hess Haus
8. Stock, Raum 8/06
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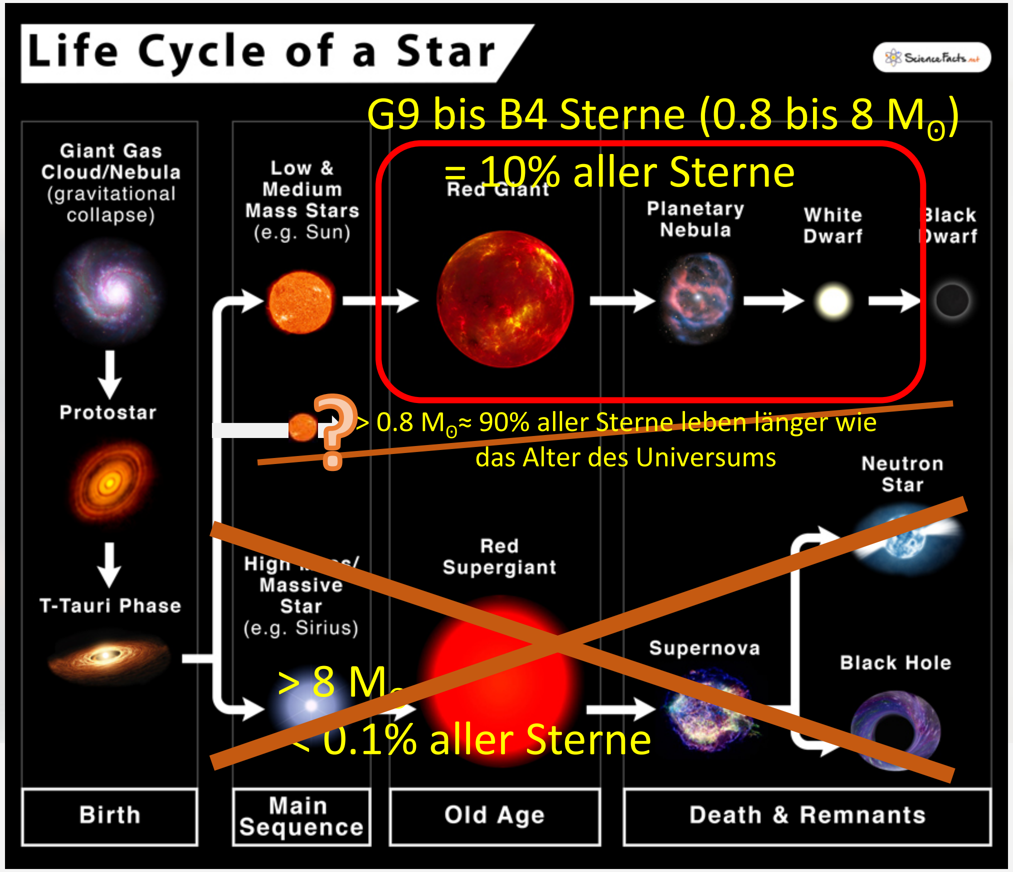
universität innsbruck

Stellare Astrophysik

Die Arbeiten dieser Gruppe fokussieren sich auf **späte Stadien der Sternentwicklung**.

Während der Schwerpunkt auf der Betrachtung und physikalischen **Interpretation von Beobachtungen** liegt, ist vor allem bei den dünnen heißen Zirkumstellaren Gasen (z.B. in den Planetarischen Nebeln) auch die **Modellierungen** der komplexen **quantenmechanischen Prozesse** und **der verbotenen Linien** aus den metastabilen Zuständen ein wichtiges Arbeitsgebiet.



Stellare Astrophysik

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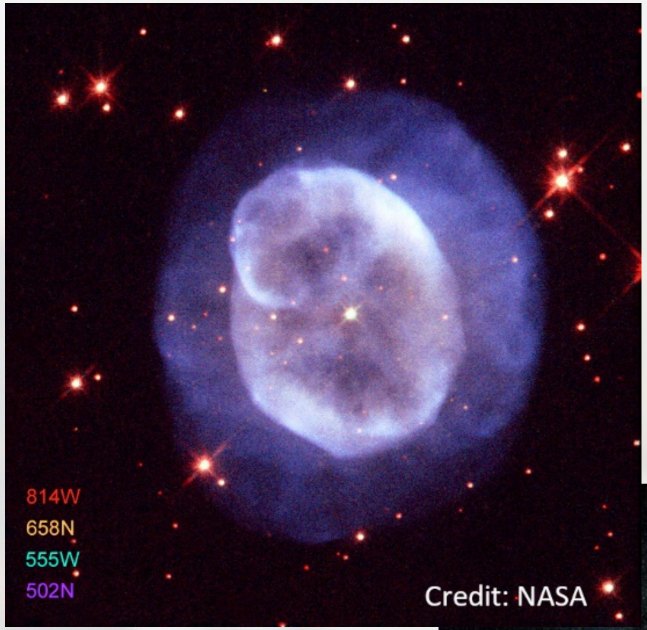
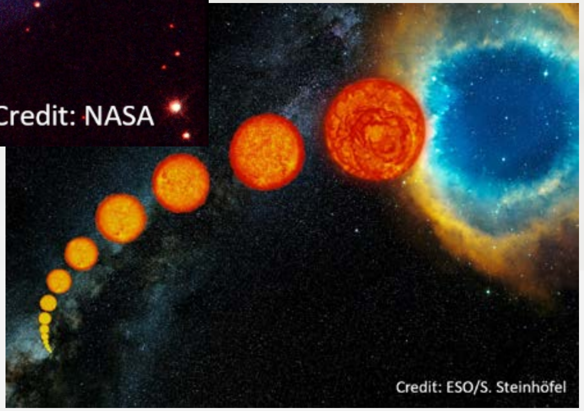
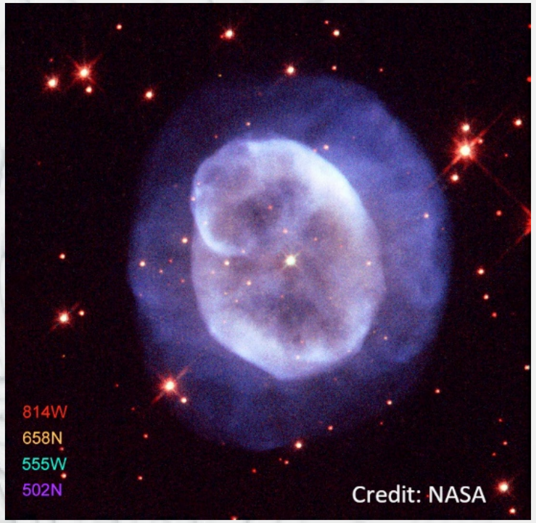
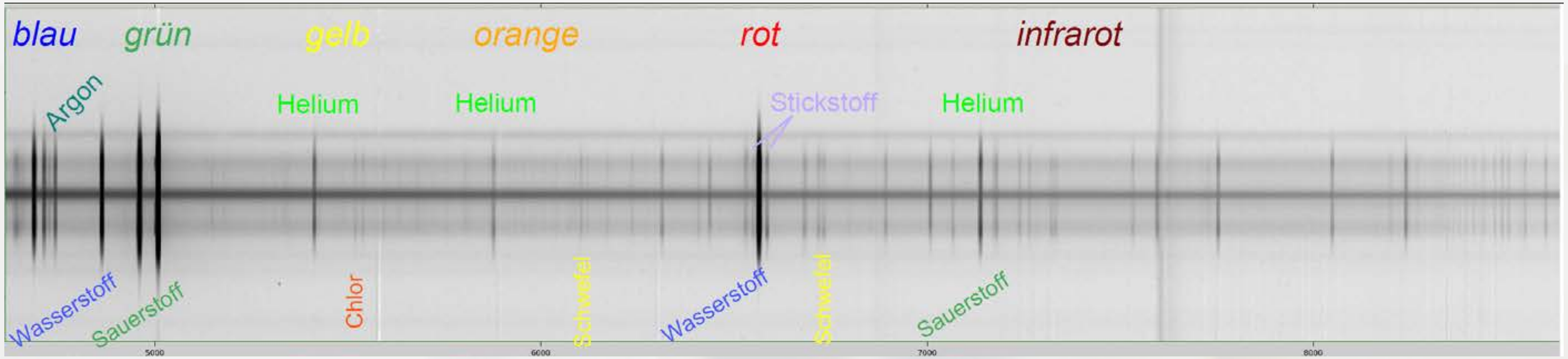


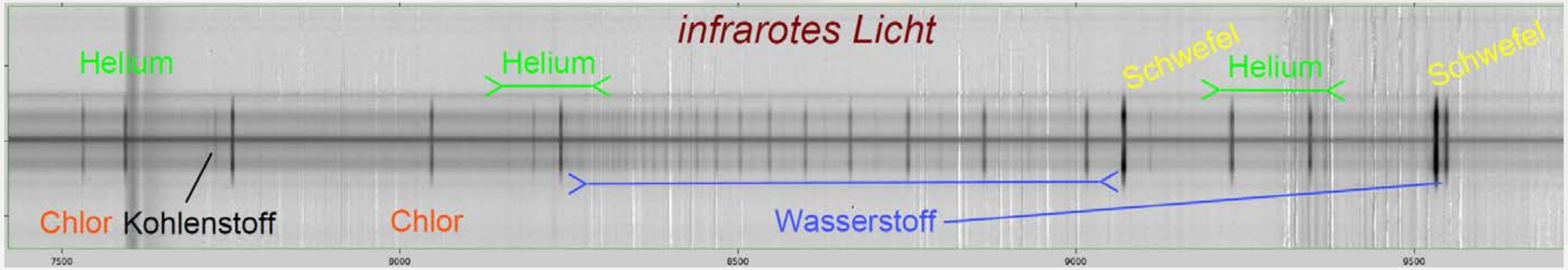


Stellare Astrophysik

BSc (+ MSc)
Thesis Projekte





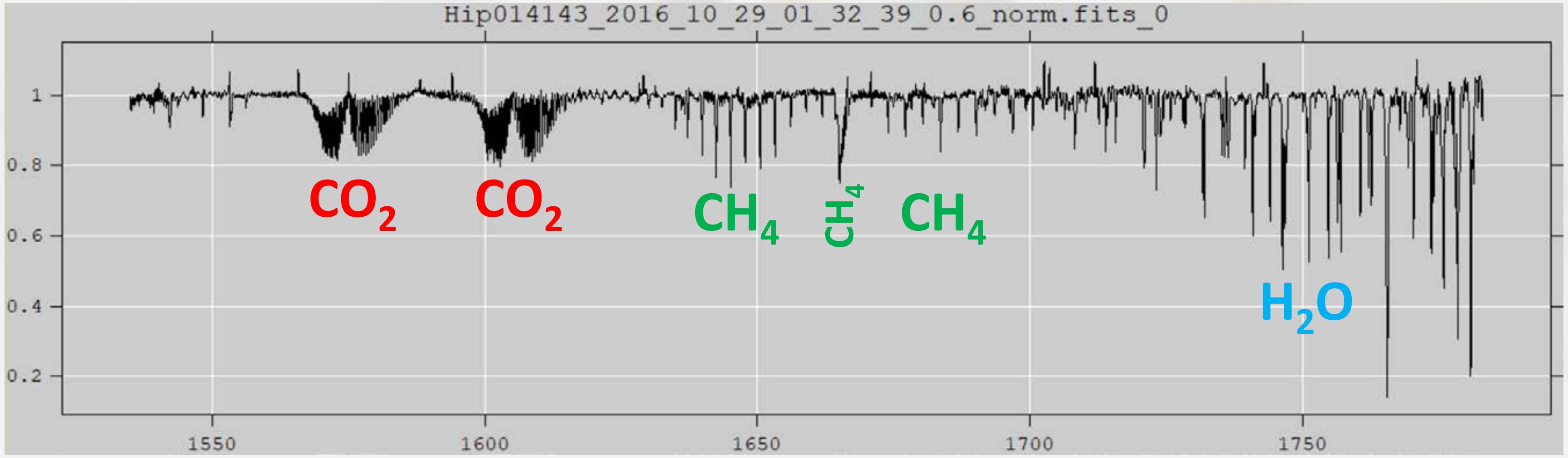


Spektren, gewonnen an von den chilenischen 8m Großteleskopen, dienen zur genaueren Untersuchung der Physik (Temperatur, Dichte, …. = Quantenmechanik in der Anwendung) wie auch der Chemie solcher Nebel.

Stellare Astrophysik

Daneben sind auch viele Arbeiten welche die Verbesserung von Beobachtungsdaten betreffen im Arbeitsgebiet. Zu diesem Zweck hat unser Team im Auftrag der Europäischen Südsternwarte (**ESO**) Software entwickelt. Die Anwendung (nicht weitere Programmierung) dieser Tools (z.B. `molecfit`) ist Gegenstand von Abschlussarbeiten.

Diese führen stark auch in die Richtung der **Molekülphysik**, der **Atmosphärenforschung** und dem **Klimawandel**, aber auch der Statistik und Datenverarbeitung.



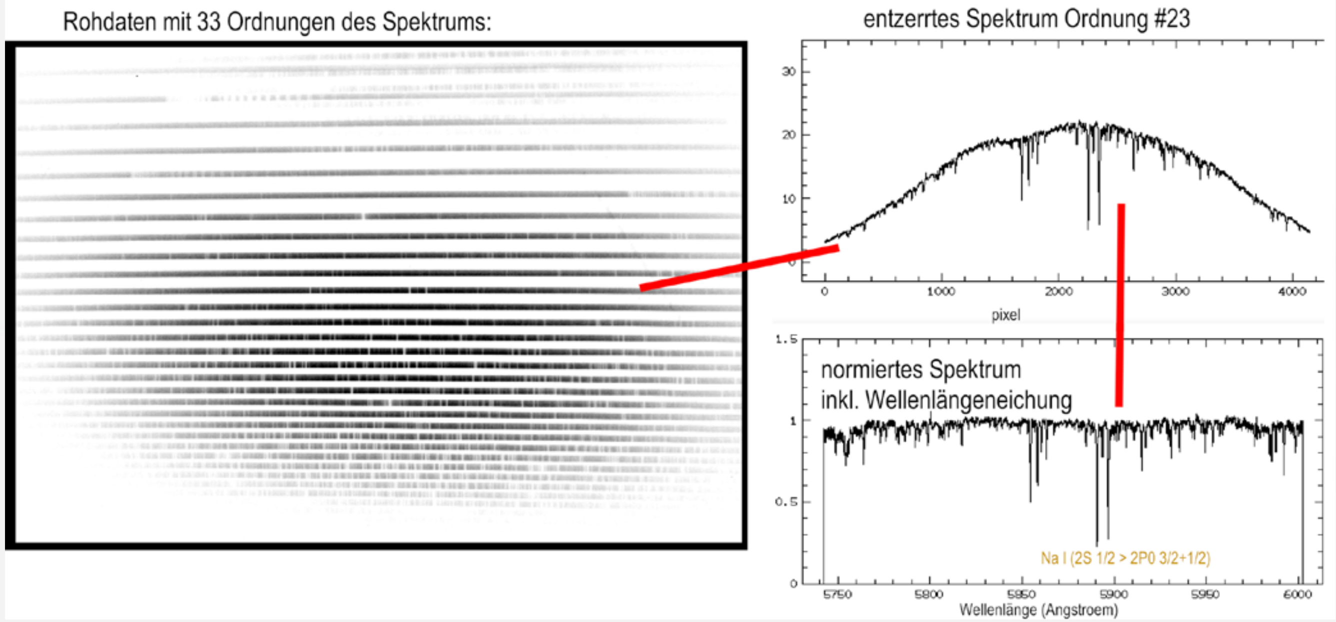
Wellenlänge [nm]

Stellare Astrophysik

Für all dies benötigt man INSTRUMENTE. Neue Instrumente benötigen grundlegende Untersuchung der Eigenschaften (comissioning). Das Institut beschaffte einen neuen Spektrographen – BACHES (Konstruktion des Max Planck Instituts für Extraterrestrische Physik)

Diese führen stark
auch in die Richtung der
der Statistik
und **Datenverarbeitung**.
Aber in dieser Arbeit sind auch eigene **BEOBACHTUNGEN** vorgesehen.

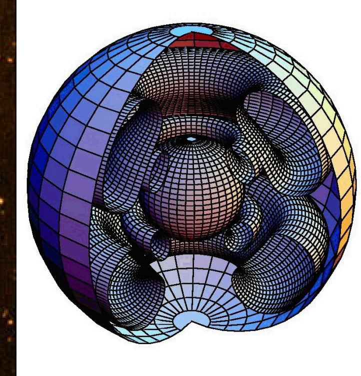
Ein weiterer noch besserer Spektrograph für das neue Teleskop der Gruppe Quanteninformation ist in Beschaffung. Dieser wird Ende 2024 (vorerst am 60cm) einsatzbereit sein und ermöglicht die Erweiterung zu einer MSc Arbeit.

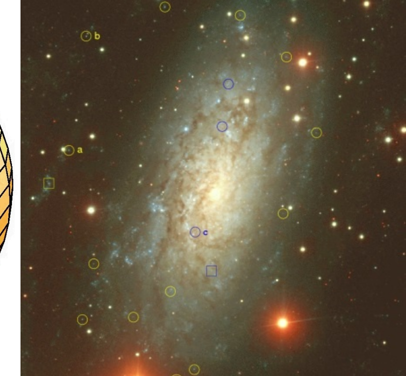


$$n_i \sum_{j \neq i} (R_{ij} + C_{ij}) =$$

$$\sum_{j \neq i} n_j (R_{ji} + C_{ji})$$

$$\mu \frac{\mathrm{d}I_\nu}{\mathrm{d}\tau_\nu} = I_\nu - S_\nu$$





Galaktische Astrophysik

& Quantitative Spektroskopie

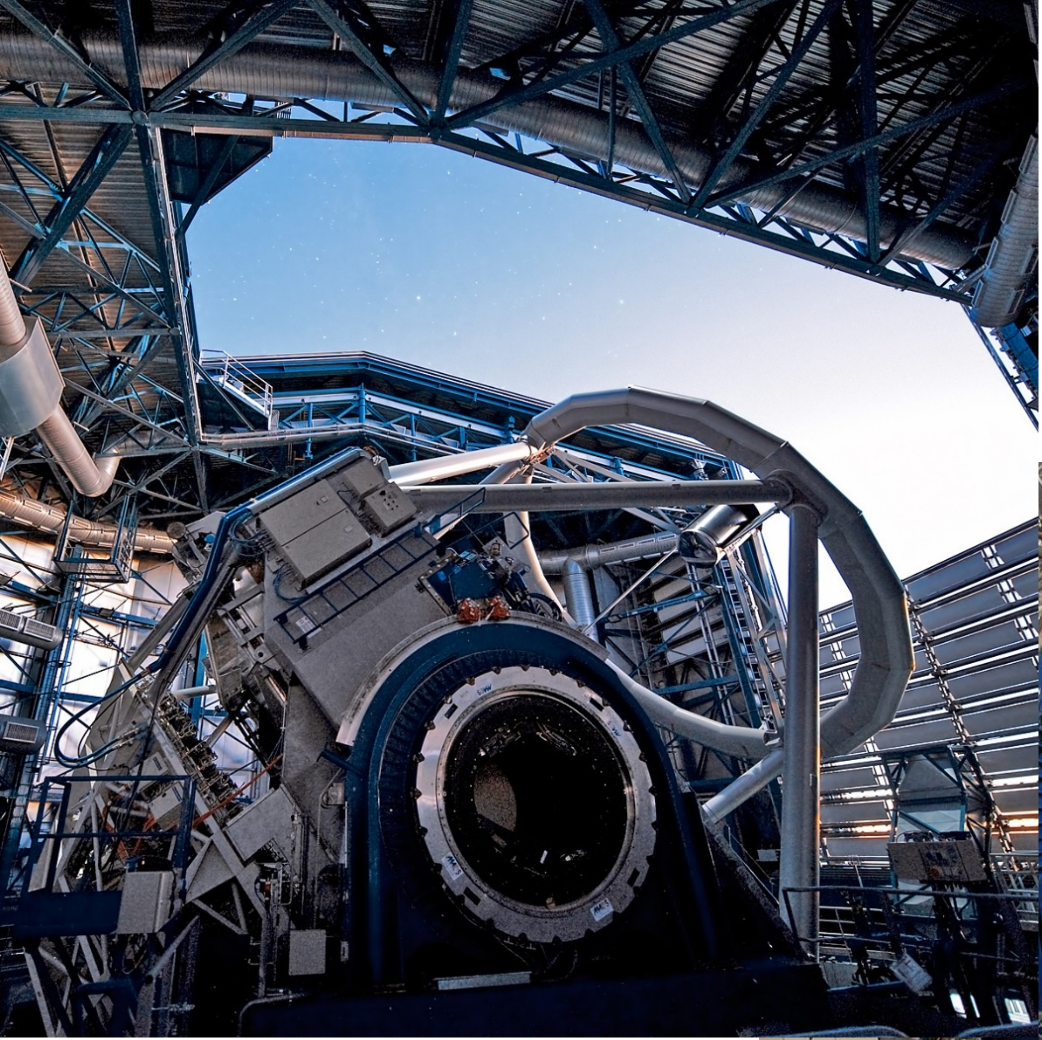
Norbert Przybilla

universität innsbruck

Institut für Astro- und Teilchenphysik

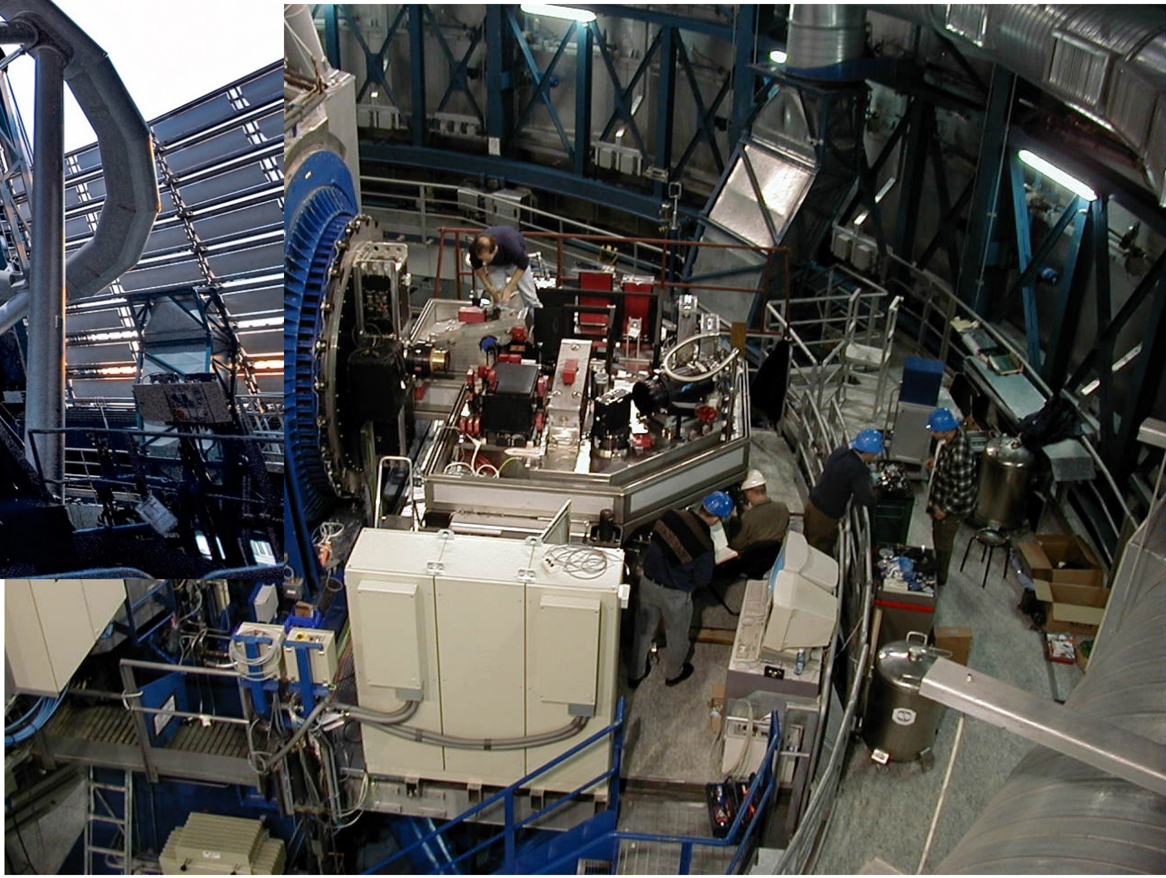
Unsere “Labs”

Unsere “Labs”



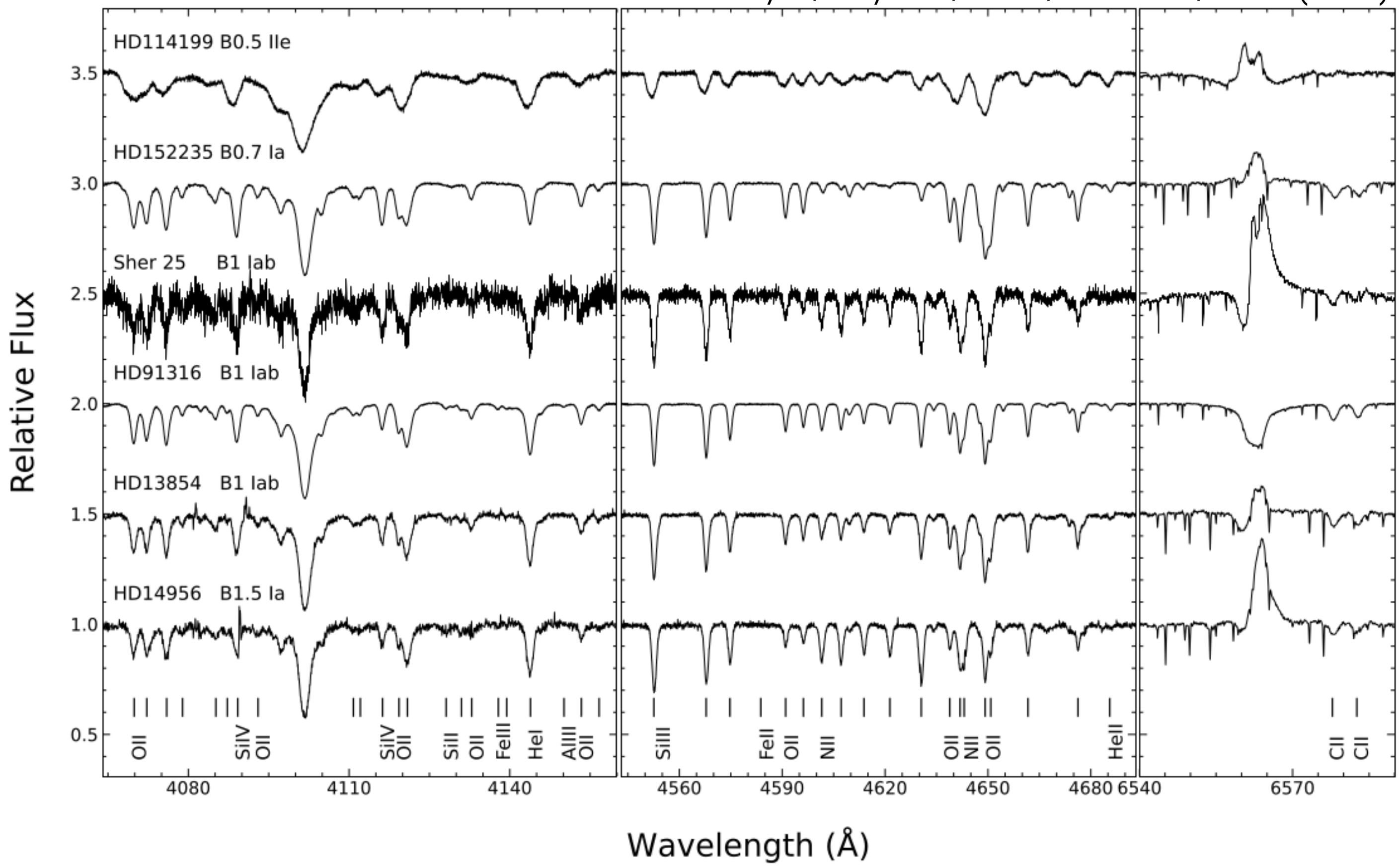
ESO VLT

ESO VLT: UVES Spektrograph



Quantitative Spektroskopie

Weßmayer, Przybilla, et al., A&A 677, A175 (2023)



Effektivtemperatur, Schwerebeschleunigung, Mikro-/Makroturbulenz, Rotation, Metallizität, **detaillierte Elementhäufigkeiten**, Masse, Radius, Leuchtkraft, Distanz, interstellare Extinktion …

Vollständige Charakterisierung von Sternen und ihrer ISM Sichtlinien

Arbeitsgebiete

- Sternatmosphären
- Strahlungstransport
- stellare Magnetfelder
- Sternentwicklung
- ISM
- Galaktische Häufigkeitsgradienten
- Extragalaktische Stellarastronomie
- Galaxienentwicklung
- Kosmische Entfernungsskala
- Instrumentenentwicklung fürs ELT
- ...

Themen Bachelor-Theses

Kinematik massereicher Sterne in der Milchstraße

Kinematics of massive stars

Supervisor: Univ.-Prof. Dr. Norbert Przybilla
Field of work: Stellar Kinematics

The Gaia space observatory of the European Space Agency provides astrometric measurements of unprecedented accuracy and precision for almost two billion sources on the sky. Main data products are parallaxes and proper motions, that are continuously improved with increasing measuring time. The current state-of-the-art is Gaia Data Release 3 (DR3), based on 34 months of observations (out of $>$10 years of mission duration).

In the proposed Bachelor thesis relevant data for massive early-type stars will be extracted from the Gaia DR3 database and radial velocities from other astronomical databases. The focus will then be on the determination of trajectories from the 6D data (spatial coordinates, space motion) of the stars in the Galactic gravitational potential by numerical integration of the orbits, and the visualisation of the positions and the trajectories in the Milky Way in a similar fashion like shown in the figure. A valueable by-product will be the identification of stars with peculiar trajectories, for future in-detail studies of these objects.

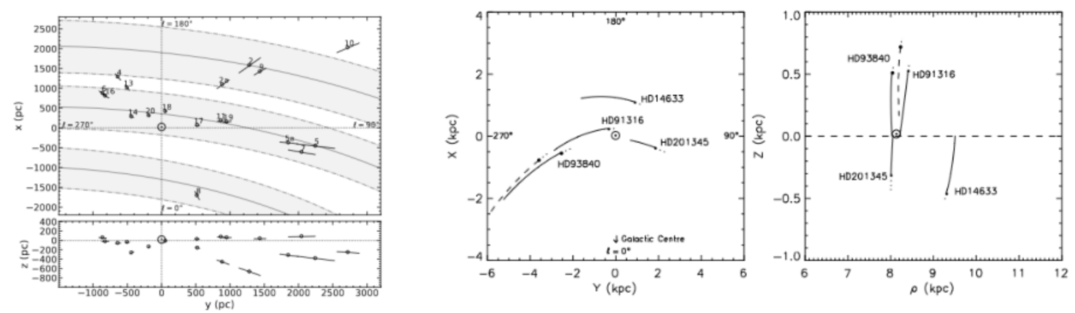


Figure: Examples of the distribution (left panel) and kinematic movement (two right panels) of massive stars in the Milky Way. Displayed are views of the Galactic plane (X-Y) and a cut through the Galactic disk (Y-Z), with the grey-shaded areas indicating thepositions of the spiral arms. The kinematics plots concentrate on massive runaway stars that were ejected perpendicular to the Galactic plane via dynamical ejection or by binary supernova disruption (Aschenbrenner et al. 2023; Weßmayer et al. 2024).

Keywords: Gaia mission – distribution and kinematics of stars – massive stars – early-type stars – astronomical databases – numerical orbit calculation

Contact: norbert.przybilla@uibk.ac.at

Themen Bachelor-Theses

Know your star,

know your planet

Quantitative spectroscopy of the exoplanet host star μ^2 Scorpii

Supervisor: Univ.-Prof. Dr. Norbert Przybilla
Field of work: Quantitative spectroscopy

The discovery of exoplanets was one of the greatest scientific achievements in astrophysics of the last three decades, and was awarded with the Nobel Prize in Physics 2019 to Michel Mayor and Didier Queloz. An overview of the current status of the search for exoplanets can be found at exoplanet.eu. Initially, only indirect methods of searching for exoplanets - e.g. the radial velocity and transit method - were successful. From 2008 onwards, direct imaging of exoplanets was realised, in particular with the aid of adaptive optics and coronography. One of the unusual findings of recent times was a planetary system around the massive supernova progenitor star μ^2 Scorpii (see the figure, Squicciarini et al. 2022, *Astronomy & Astrophysics*, 664, A9 doi:10.1051/0004-6361/202243675).

The proposed bachelor thesis focuses on the host star μ^2 Scorpii, of spectral type B2 IV. A spectral analysis on the basis of an existing high-resolution spectrum is to be carried out. In particular, the chemical composition is of interest. Modern line-formation calculation codes together with analysis codes are to be applied in order to analyse the chemical composition, taking into account deviations from the standard assumption of thermodynamic equilibrium (so-called non-LTE effects) to determine abundances for the astrophysically most important elements.

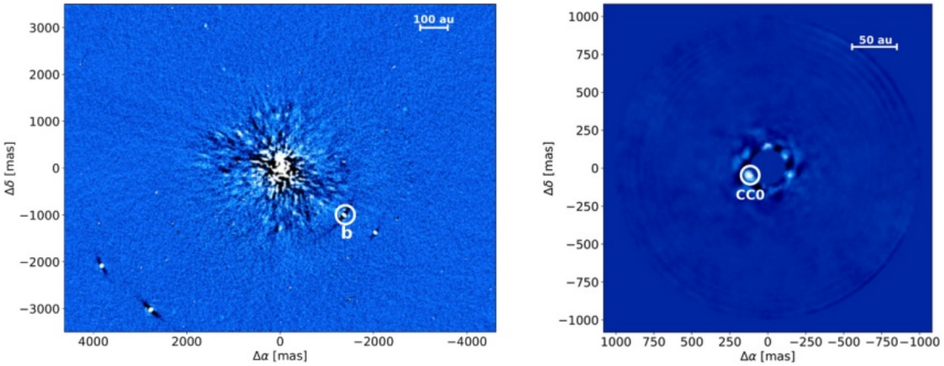


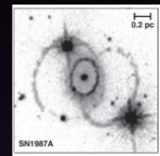
Figure: Detection of the substellar companions μ^2 Sco b and c via adaptive optics. The light from the bright host star was suppressed via a coronograph (Squicciarini et al. 2022).

Keywords: high-resolution spectroscopy – elemental abundances – stellar atmospheres – non-LTE radiative transfer – host stars of exoplanets

Contact: norbert.przybilla@uibk.ac.at

Themen Master-Theses

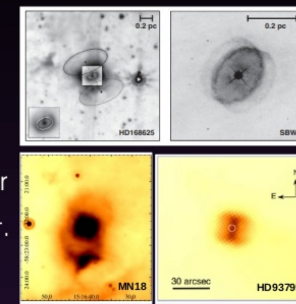
Master Theses Topics in Galactic Astrophysics
Univ.-Prof. Dr. N. Przybilla



Taylor et al. 2014

SN1987A progenitor siblings

Quantitative analysis of high-resolution spectra of B-type supergiants with bipolar outflows in analogy to the precursor star of SN1987A.
Determination of their atmospheric and fundamental stellar parameters, and their chemical composition; constraints on their evolutionary status, in particular w.r.t. a stellar merger scenario.



Taylor et al. 2014

Gvaramadze et al. 2015, 2020

D. Malin/AAO

Massive stars in the Magellanic Clouds

Benchmark abundances for the LMC and SMC.
The metallicities of the LMC and the SMC are overall constrained to ½ and $^{1}/_{5}{}^{th}$ of the solar values. Individual elemental abundances were determined by a range of studies, however significant uncertainties remain.

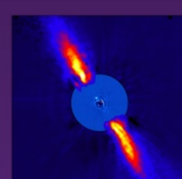
Using our advanced analysis methodology, metal abundances for massive main-sequence and blue supergiant stars shall be determined at benchmark quality. Both own data and archive spectra will be employed. This is in preparation for larger investigations that will become feasible in the future via our partnership in the Observatorio Cerro Armazones in Chile.

This work area offers possibilities for several theses.

Supergiants in NGC300 & IC1613

Own VLT/X-Shooter spectra of blue supergiant starsroup NGC300 galaxy and the metal-poor Loca Group galaxy IC1613 ($^{1}/_{3}$ to $^{1}/_{6}{}^{th}$ solar metallicity) shall be analysed. Some of the targets are supposed to be highly evolved beyond the red supergiant stage based on their pulsational properties.

ESO   DES/DOE/Fermilab/NCSA & CTIO/NOIRLab/NSF/AURA



ESO

Host stars of directly imaged exoplanets

Several warm (A- & late B-type) host stars of exoplanets have been identified in the past 15years. Building upon previous work, a sample of objects shall be fully characterised using high-resolution spectra, data from the Gaia mission and various other data sources. – Know your star, know your planet (better).

In case of interest contact N. Przybilla, Office 8/27, norbert.przybilla@uibk.ac.at
Institut für Astro- und Teilchenphysik, Technikerstr. 25/8

These topics are suggestions. Additional topics may be arranged for individually.

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NASA/ESA/CSA/
N.B. Sabha

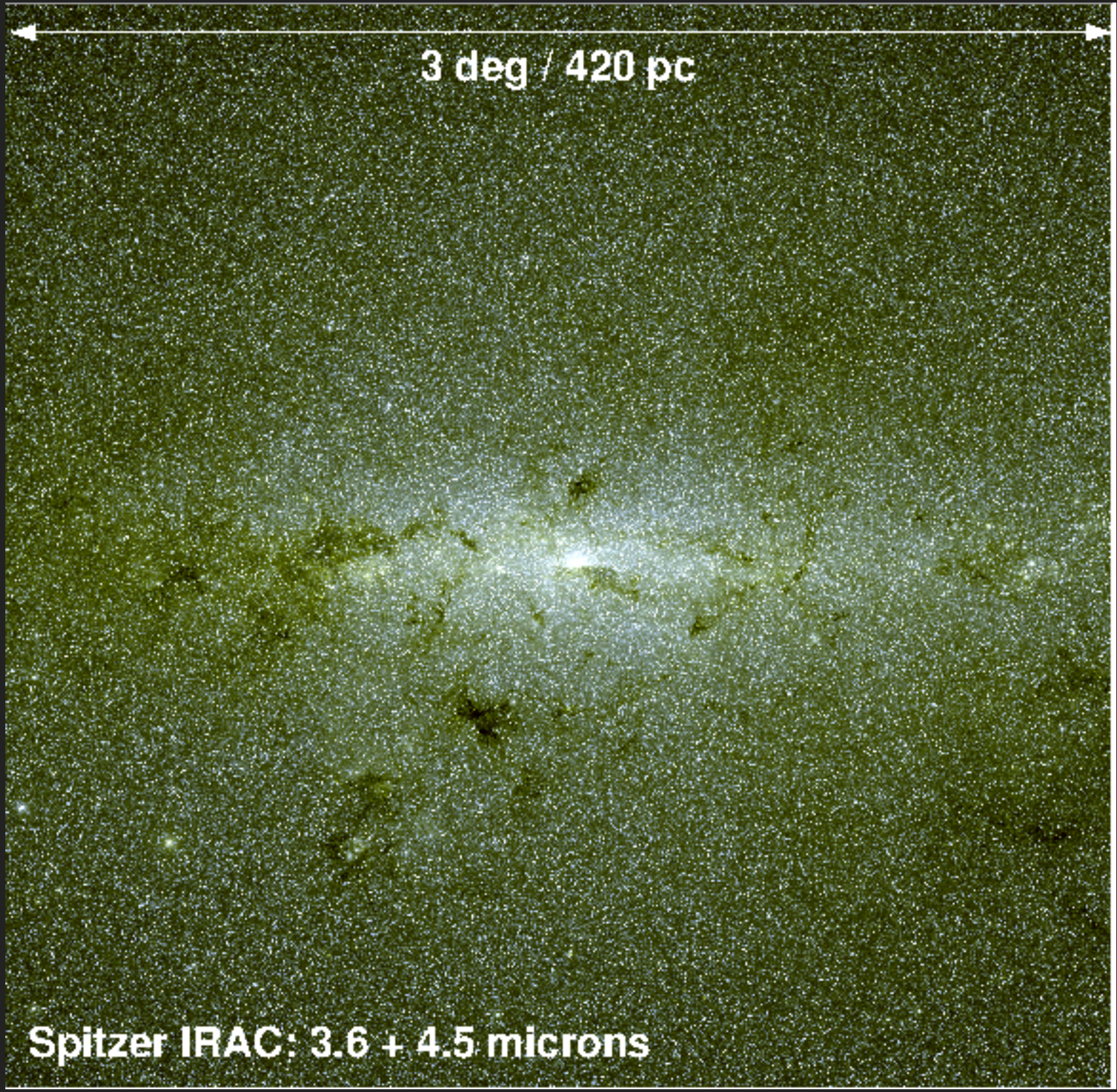
NADEEN B. SABHA

GALACTIC CENTER RESEARCH


APEX/ATLASGAL Submillimeter (~850 μm)
2
NASA/Spitzer Infrared (3.6 - 8 μm)
ESO/VISTA Near Infrared (0.85 – 2.3 μm)
Visible (0.4 - 0.7 μm)
Credit: ESO/ATLASGAL consortium/NASA/GLIMPSE consortium/VVV Survey/ESA/Planck/D. Minniti/S. Guisard

CONTEMPORARY MIR VIEW OF GC

- Distance: 8.0 ± 0.25 kpc
  (1″ = 8000 AU = 0.039 pc)
- Embedded in central 0.5 kpc of Galactic Bulge/Bar
- Region of high stellar density
- Scale radius ~230 ± 20 pc
- Scale height a few 10 pc
- Mass of $1.4 \pm 0.6 \times 10^9\ M_\odot$
  - *see Launhardt et al. (2002)*




Center of the Milky Way Galaxy
Chandra X-ray Observatory
Hubble Space Telescope
Spitzer Space Telescope
Arched Filaments
Arches Cluster
X-ray Binary 1E 1743.1-2843
Sickle
Quintuplet Cluster
Pistol Star
Sagittarius A
50 light-years
15.3 parsecs
6′35″
N
E


Center of the Milky Way Galaxy
Chandra X-ray Observatory
Hubble Space Telescope
Spitzer Space Telescope
Arches
Figer et al. (1999)
Arched Filaments
Arches Cluster
X-ray Binary 1E 1743.1-2843
Sickle
Quintuplet Cluster
Pistol Star
Sagittarius A
50 light-years
15.3 parsecs
6′35″
N
E

Center of the Milky Way Galaxy
Chandra X-ray Observatory
Hubble Space Telescope
Spitzer Space Telescope
Arches
Figer et al. (1999)
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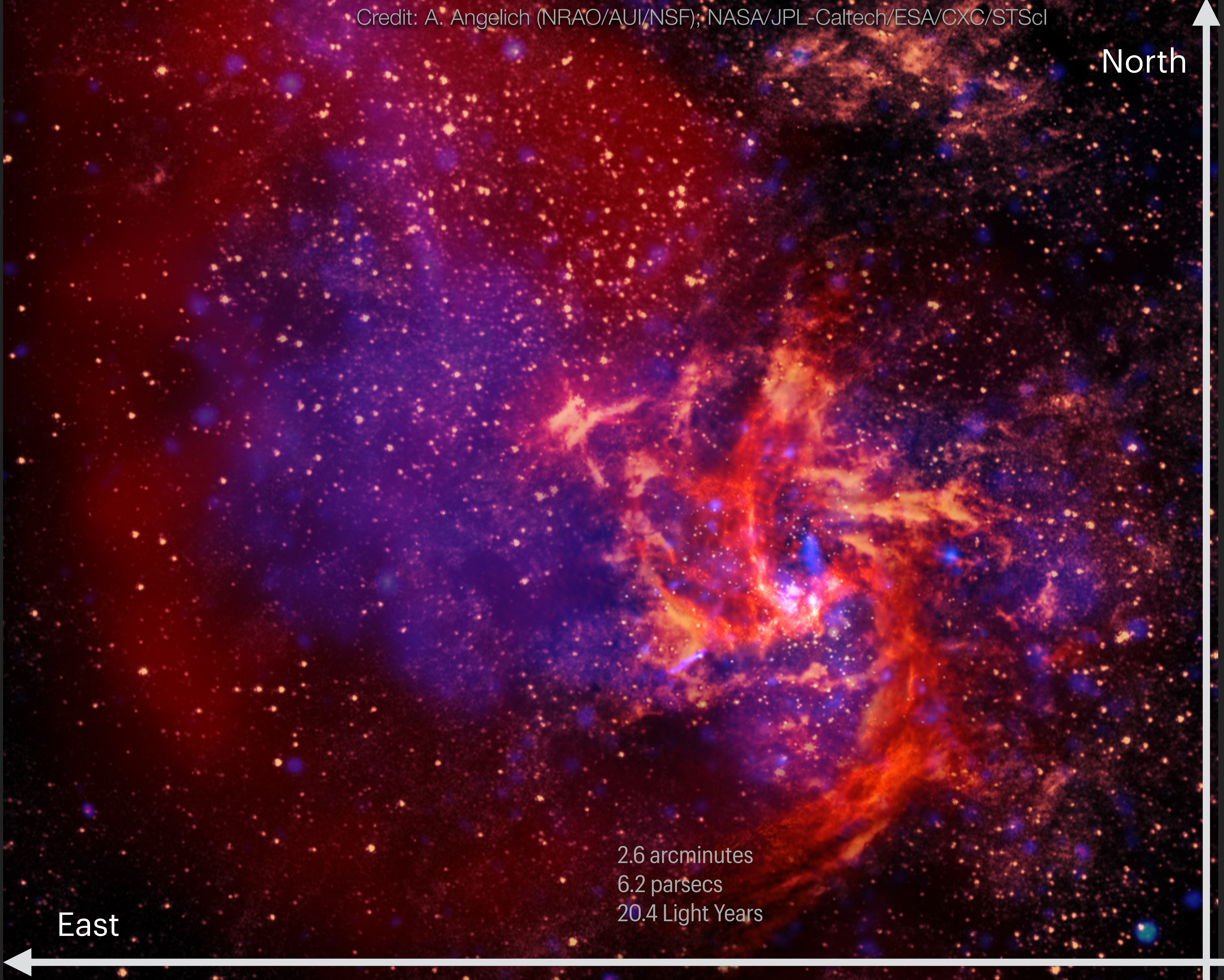
universität innsbruck

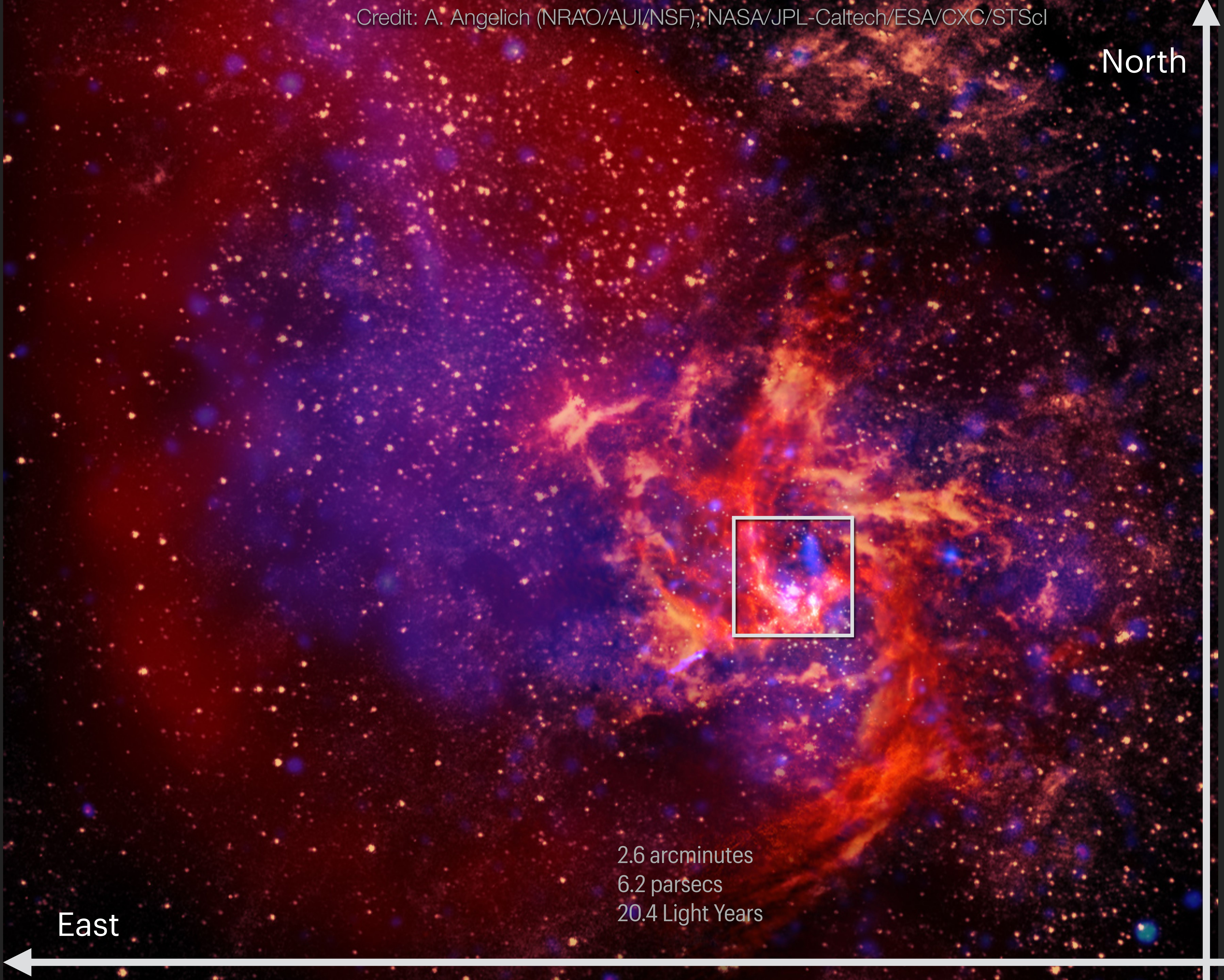
false-color
X-ray (purple),
infrared (gold),
and radio (orange/red)



2 arcminutes
4.8 parsecs
15.6 Light Years

universität
innsbruck

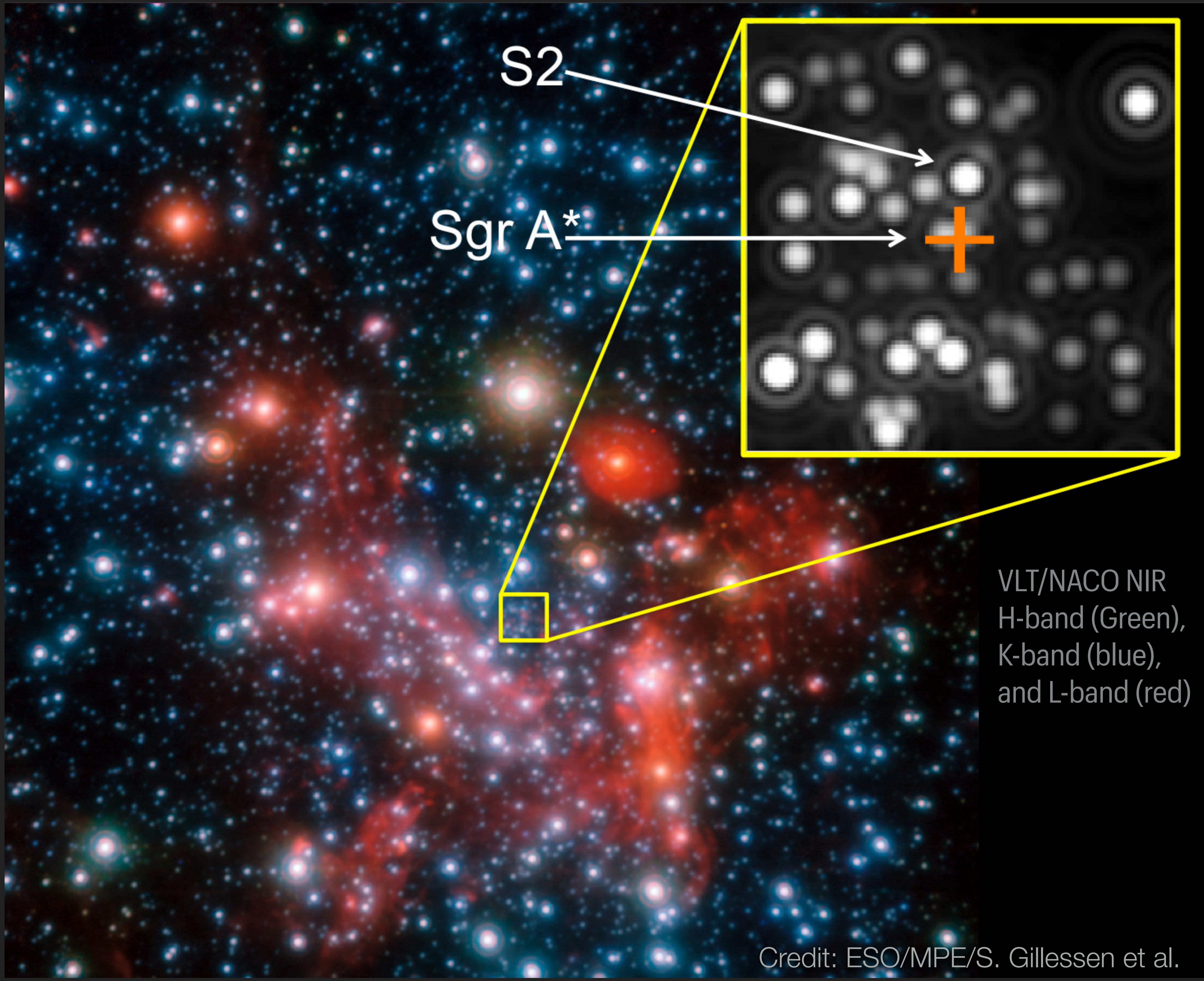
false-color
X-ray (purple),
infrared (gold),
and radio (orange/red)



2 arcminutes
4.8 parsecs
15.6 Light Years

NUCLEAR STAR CLUSTER

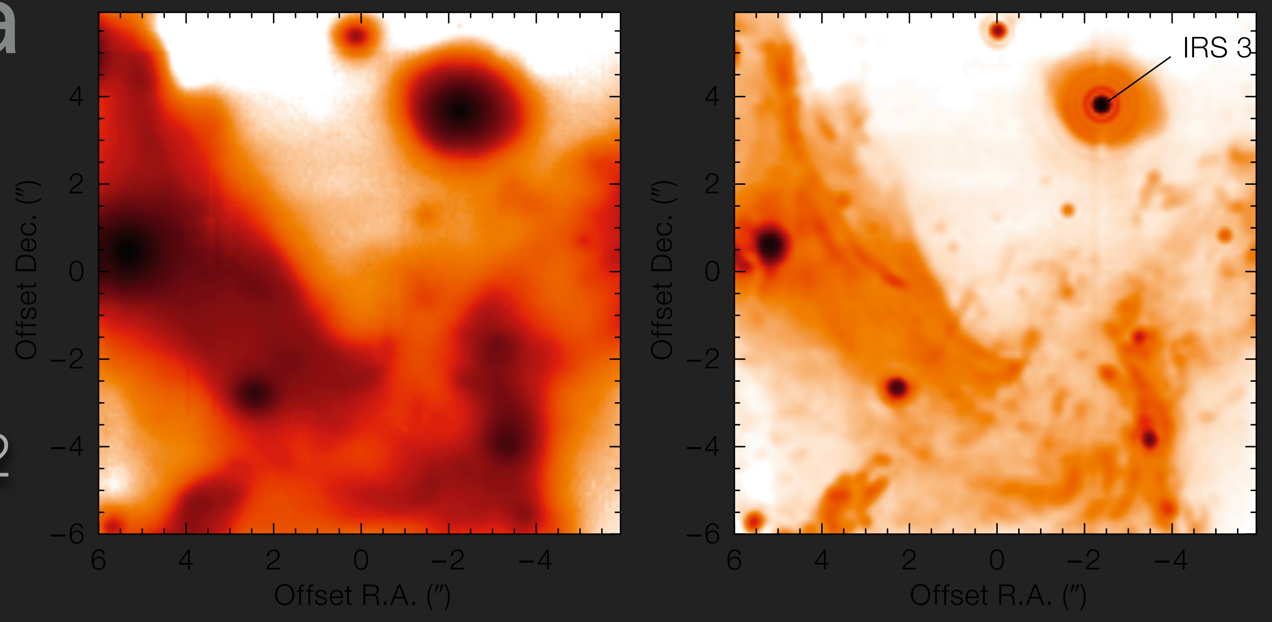
- Half light radius of 4.2 ± 0.4pc
- Mass: 2.5 ± 0.4×10⁷ M⊙
- Complex stellar population, quasi-continuous star formation history
- Central parsec cluster of young, massive stars
- Centered on 4 × 10⁶ M⊙ black hole Sagittarius A*



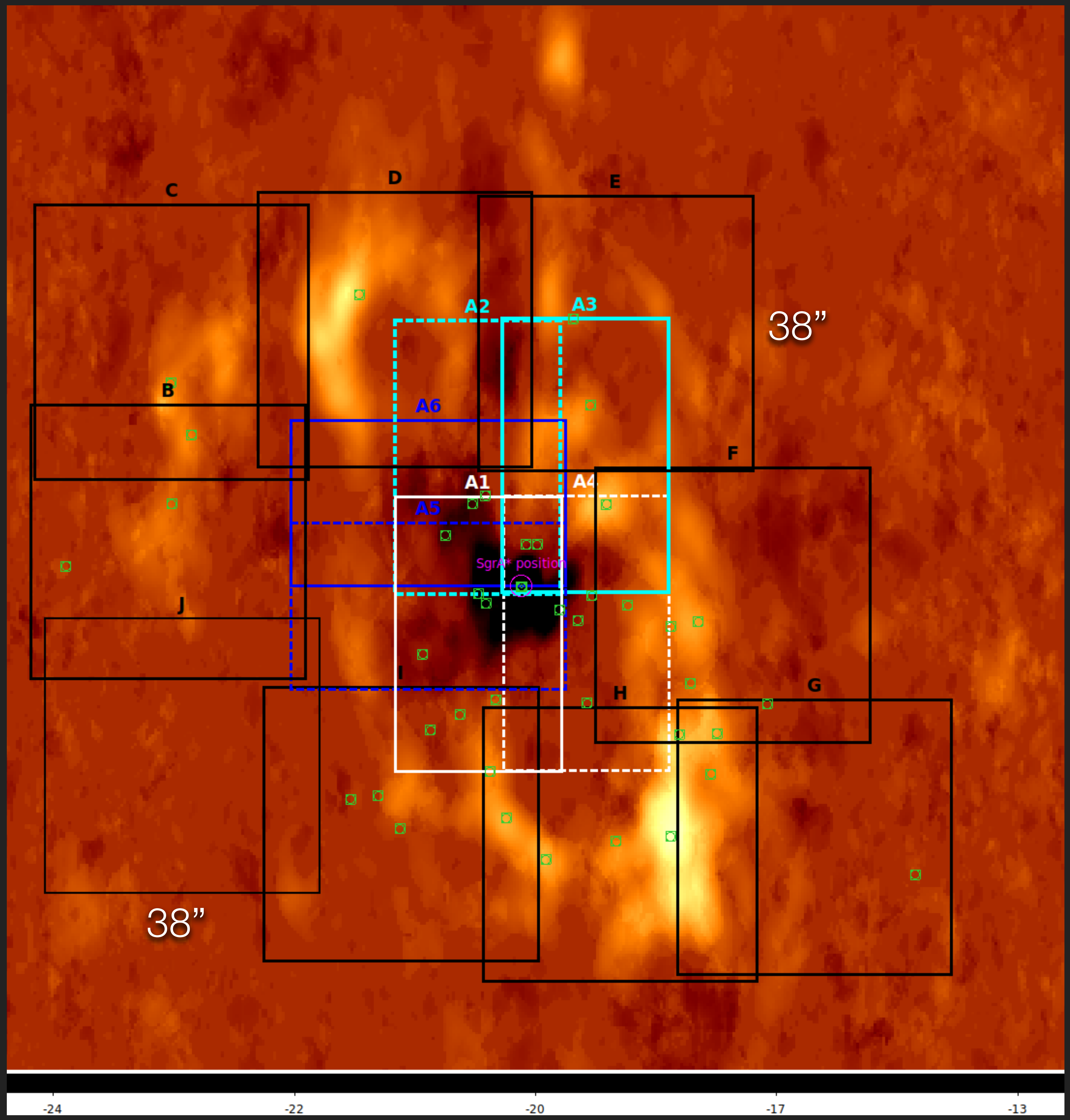
RECENT VLT/VISIR OBSERVATIONS

- Uniformly mapped the circumnuclear disk (CND) in 3 bands (5 μm, 8.6 μm, 13 μm)
- Applied BUSRT and Speckle holography to the inner fields of the data

Schödel & Girard 2012



- In search for signatures of star formation in the circumnuclear disk

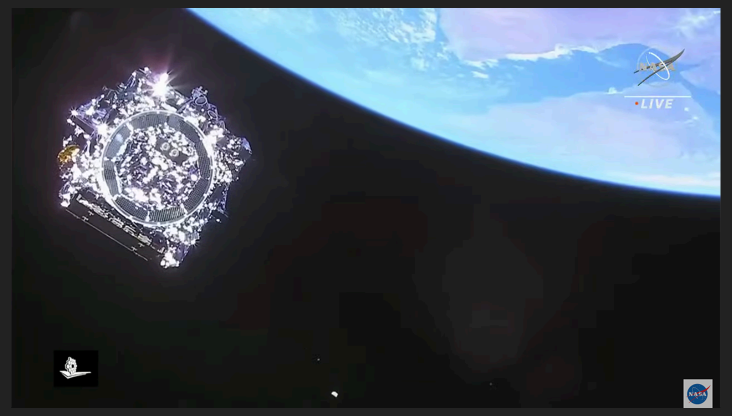


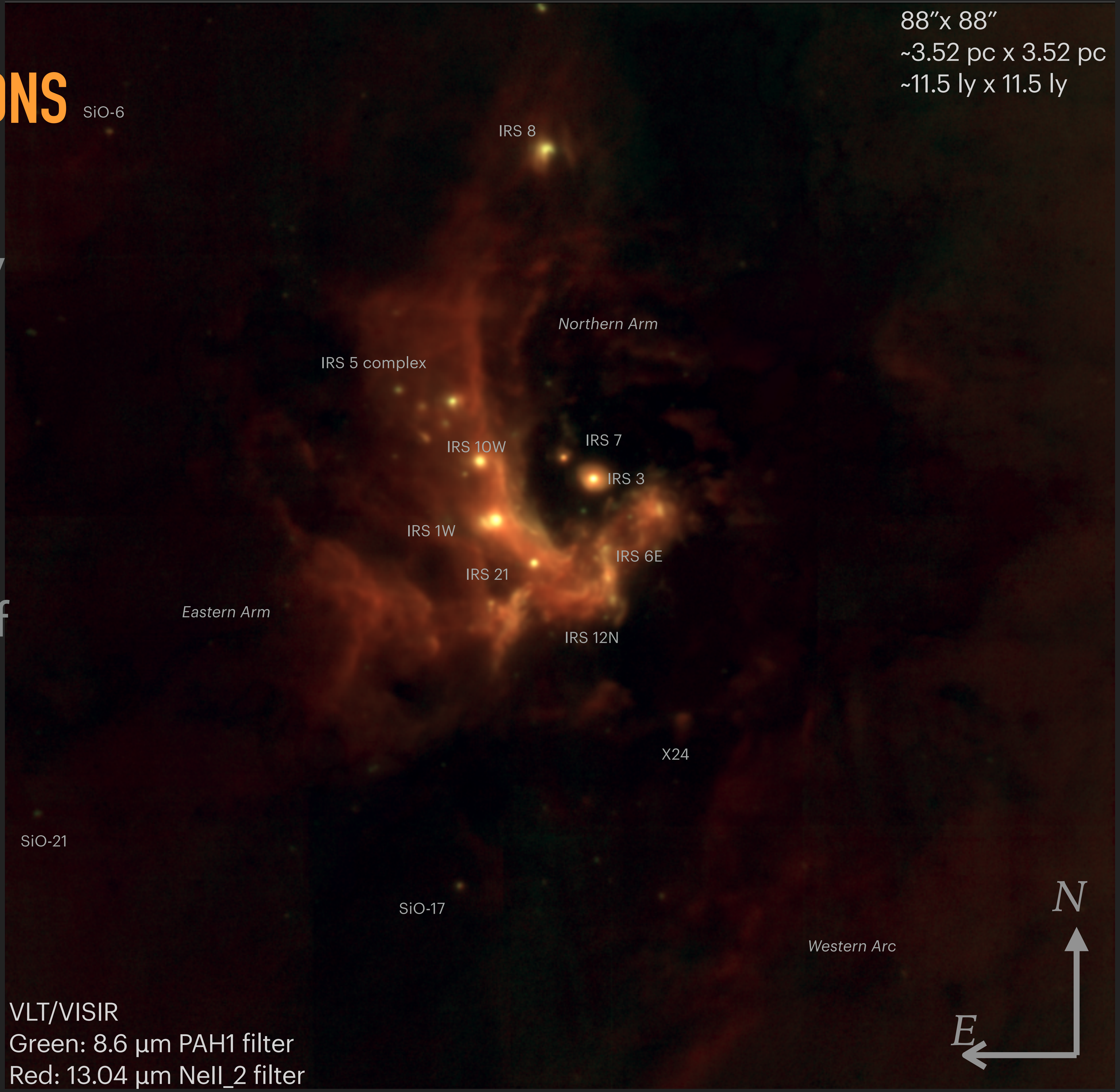
Background image is OVRO MMA HCN(1-0) map (Christopher et al. 2005)
Green square are radio SiO clumps and bipolar outflows (Yusef-Zadeh et al. 2015, 2017)
Boxes are labeled regions observed with VLT/VISIR

RECENT AND UPCOMING JWST/MIRI OBSERVATIONS

- Obtain MIRI/MRS integral field spectroscopy (IFU) data of proplyd-like (photoevaporative protoplanetary-disk like) objects

- To investigate whether they are signatures of on-going low-mass star formation within the inner parsec, as hinted by radio data





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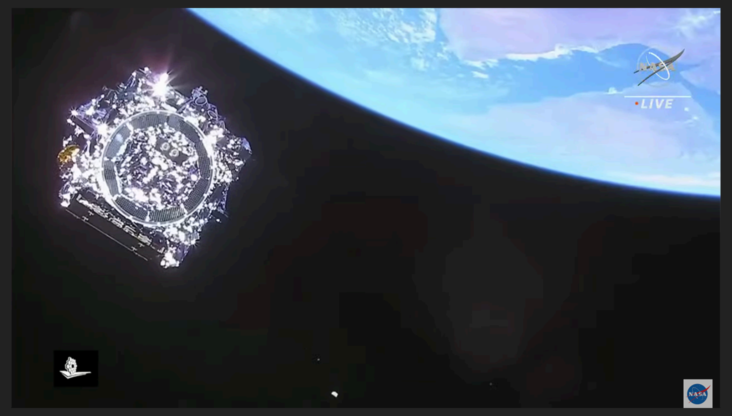

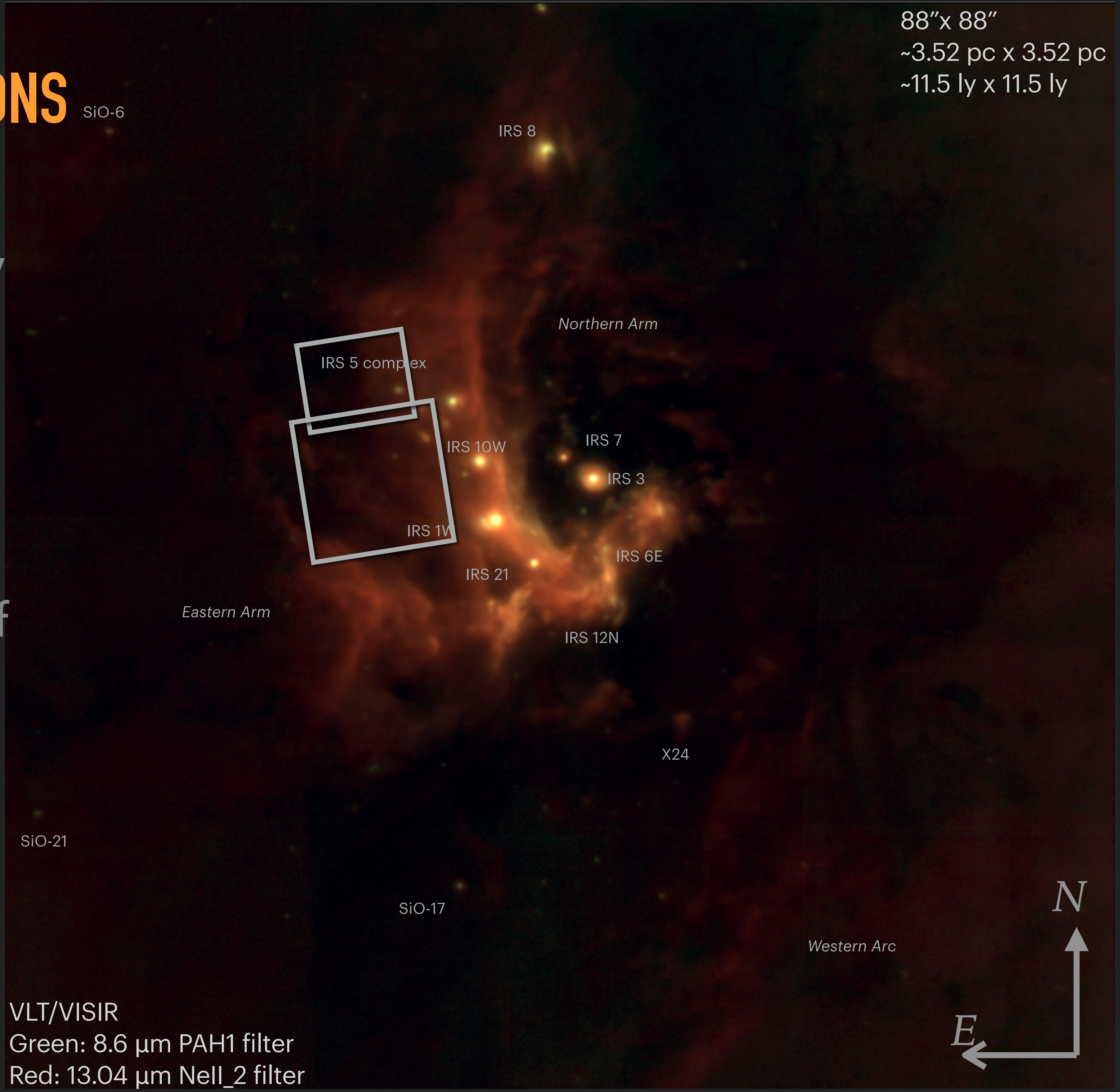

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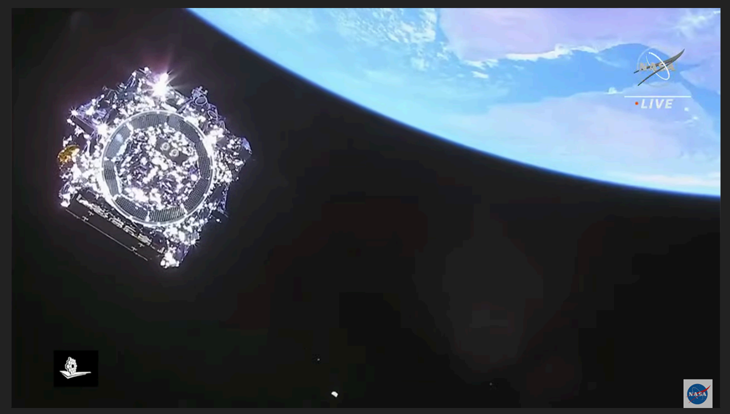
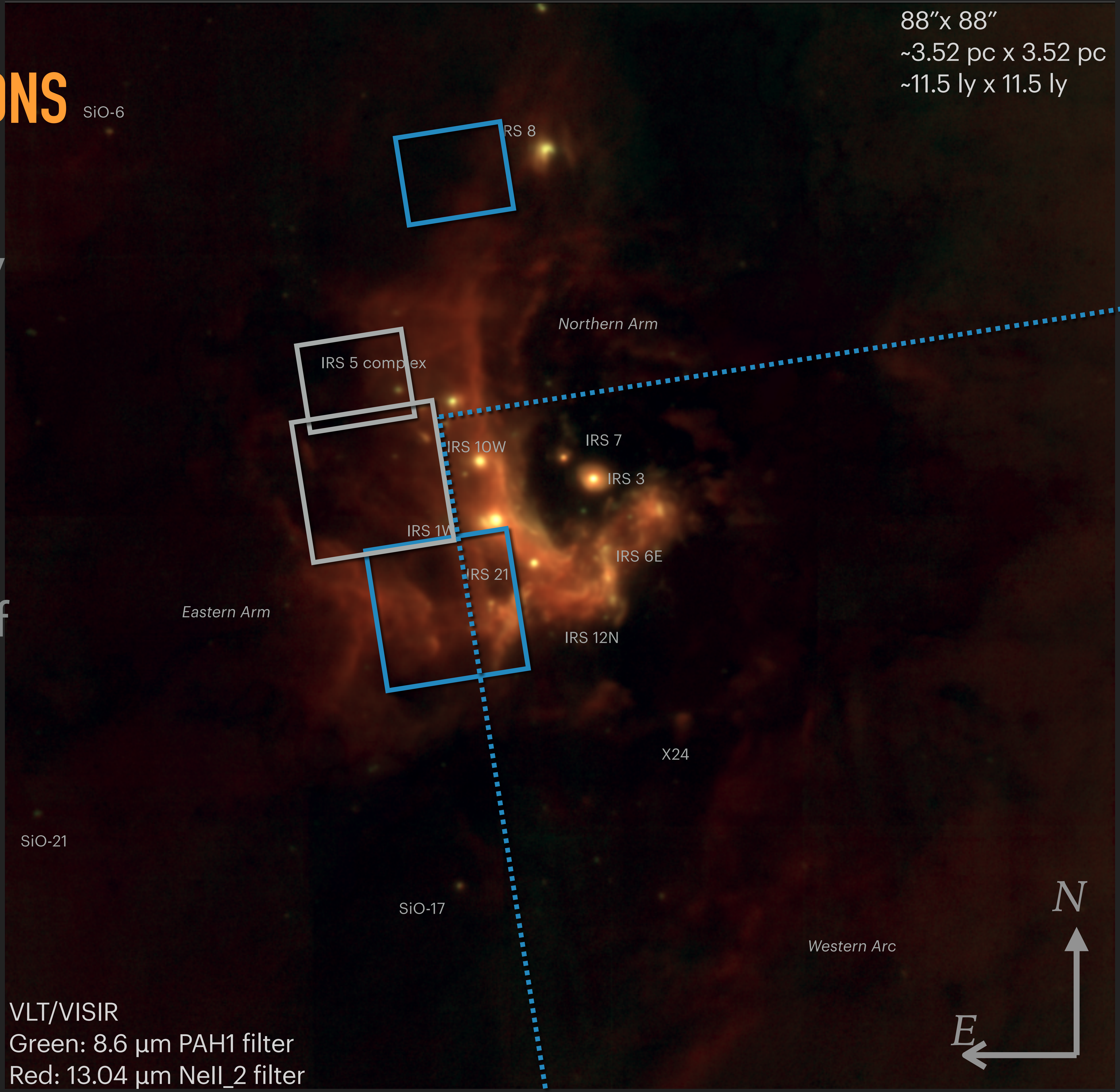
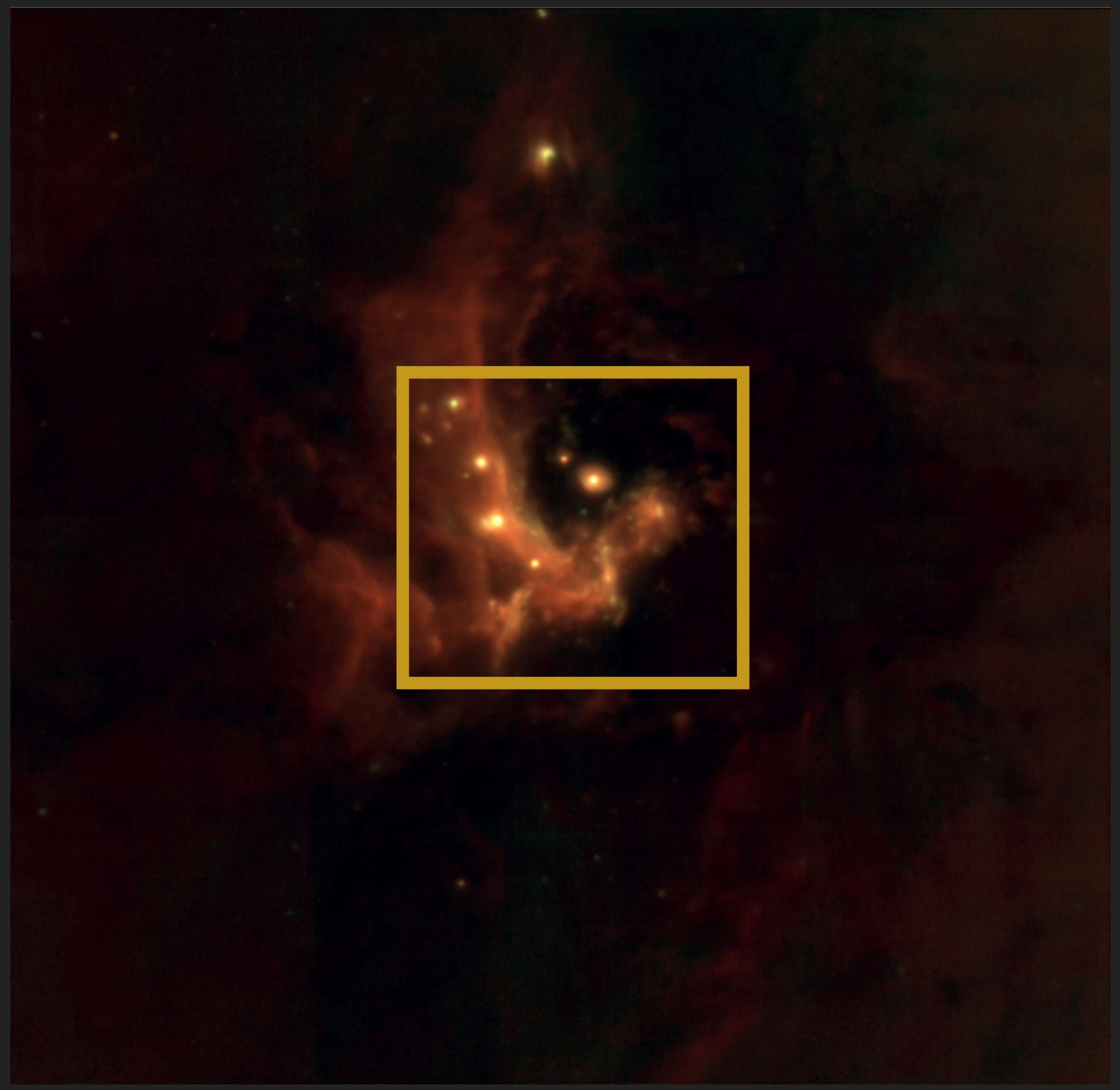
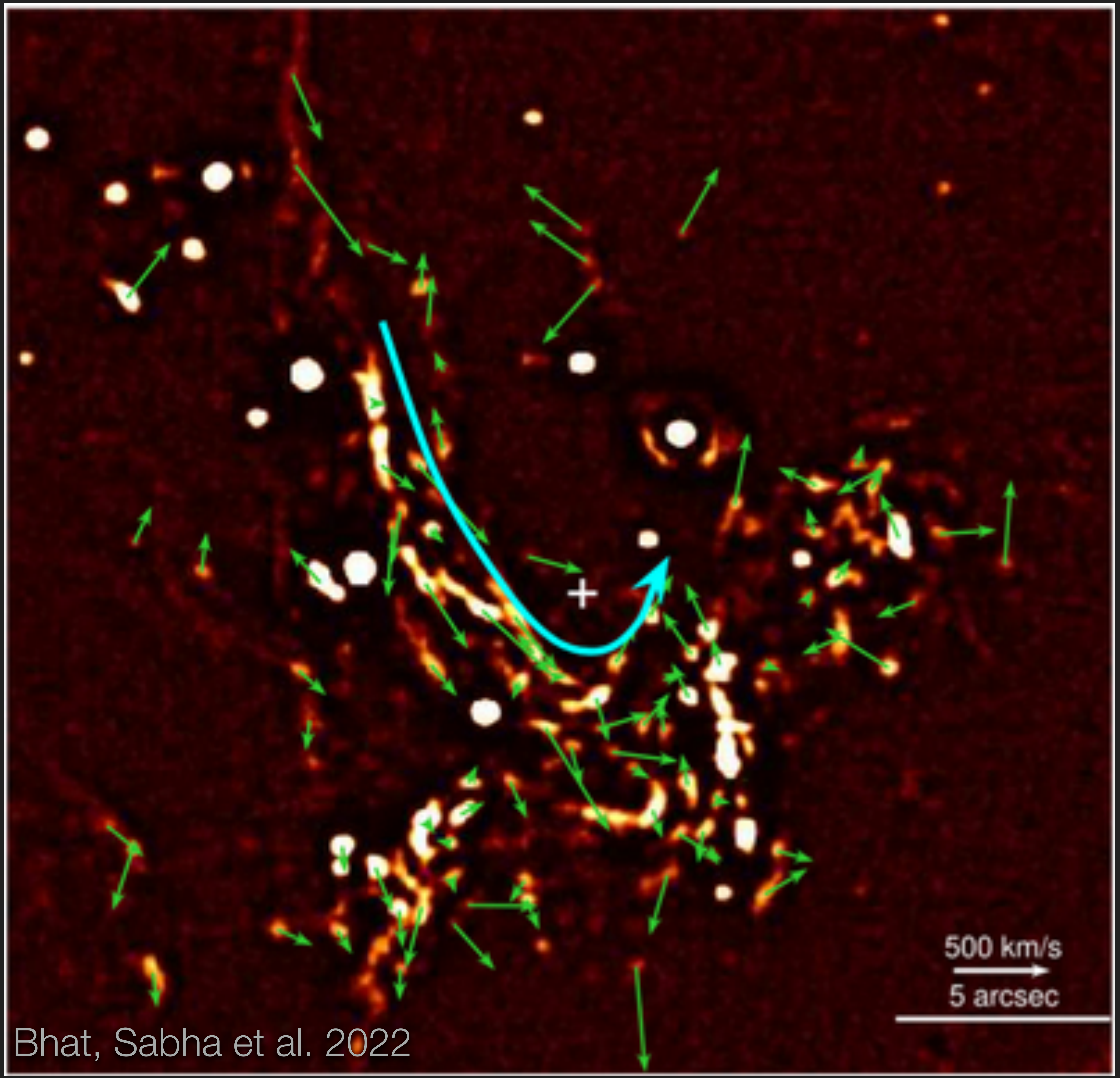




PROPER MOTIONS OVER 12 YR SPAN

- VLT/VISIR
- 8.6 μm PAH1 high-pass filtered image





MASTER TOPIC: PROPER MOTION STUDY OF MIR DUSTY SOURCES IN THE NUCLEAR STAR CLUSTER

- Using ground-based VISIR data spanning more than 12 years of the inner 5 parsecs of the Galactic Center
  - SiO masers, bowshock sources, dusty filaments
- Complementary data: MIR NeII cube (archive), recent JWST MIRI/MRS data
- Cross-correlation with associated sources in the shorter NIR (GalacticNucleusSurvey) and longer wavelength bands (radio, e.g. Zhao et al. 2009)
- Steps include: data matching, coordinate transformation, proper-motion measurement, potential orbit analysis, visualization, paper writing

THANK YOU!

Contact:
Nadeen B. Sabha

nadeen.sabha@uibk.ac.at

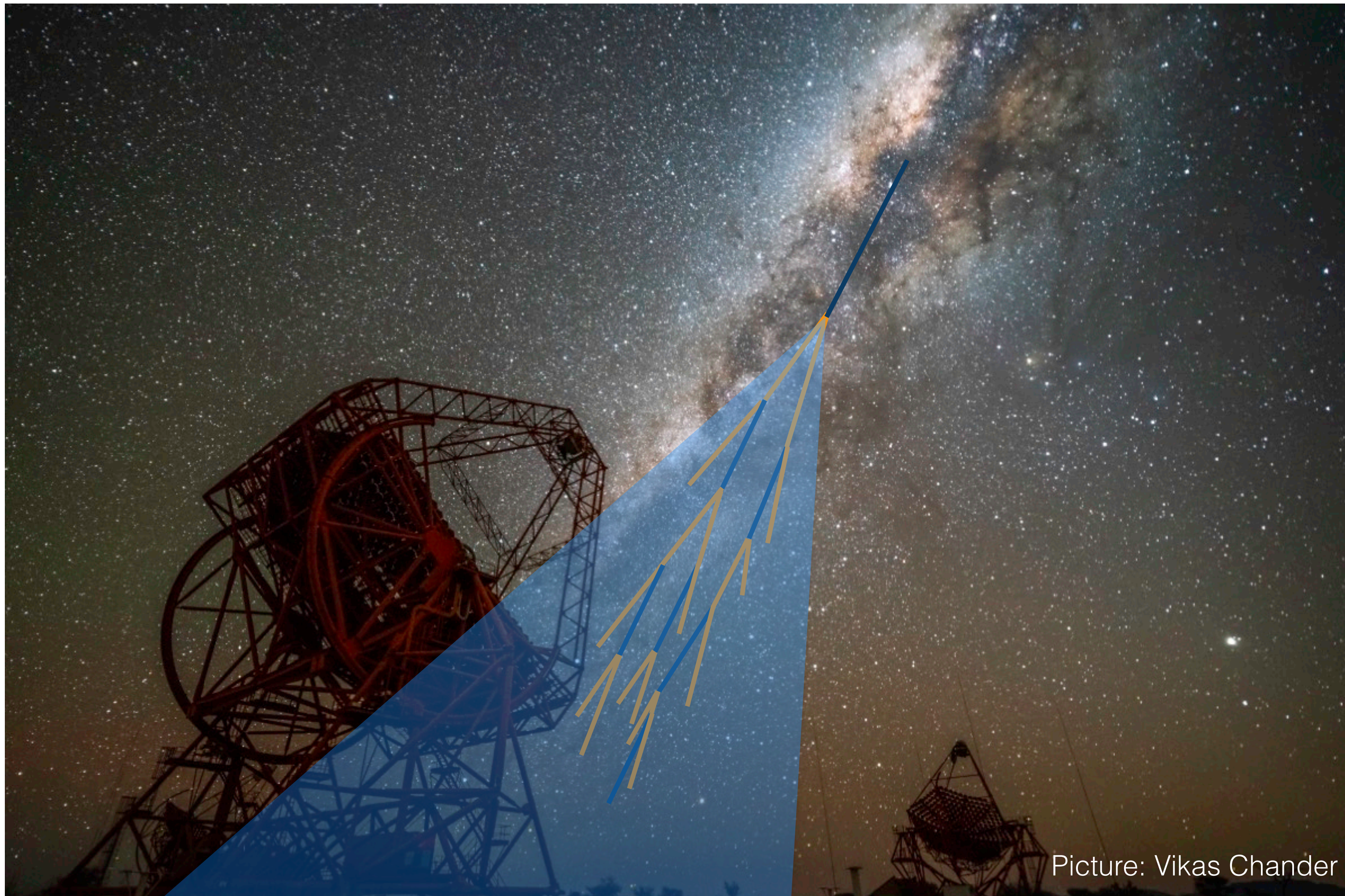
Technikerstr. 25,
8th floor, Room 8/29

Bachelorarbeiten in der experimentellen Astroteilchenphysik

Markus Holler

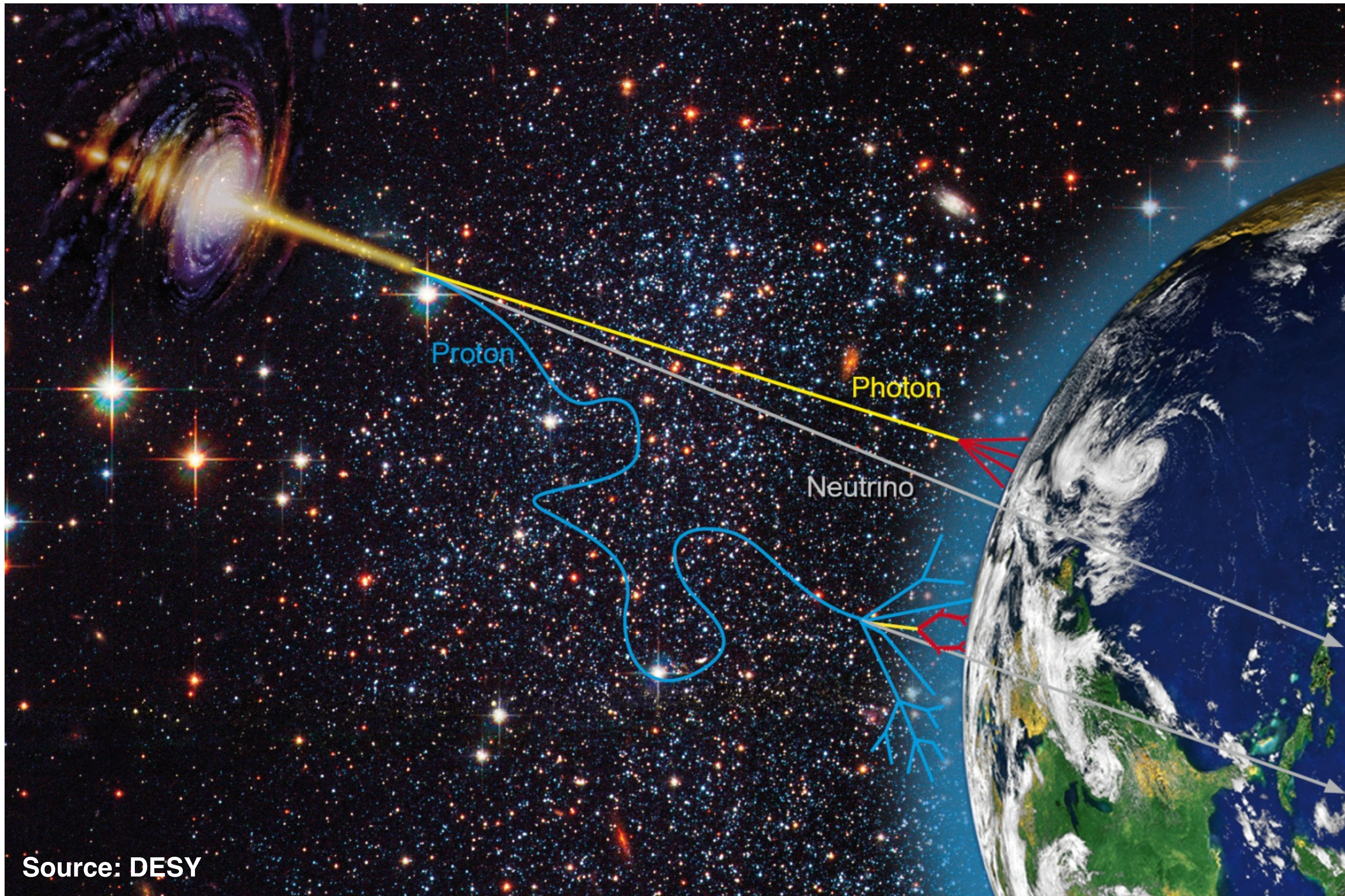
10. Januar 2024

universität innsbruck

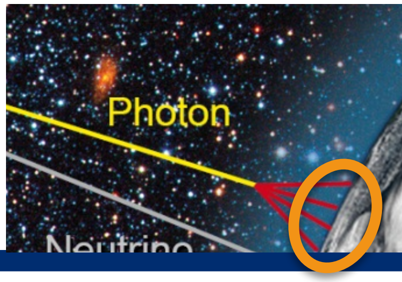


Astroparticle Physics and Gamma-Ray Astronomy

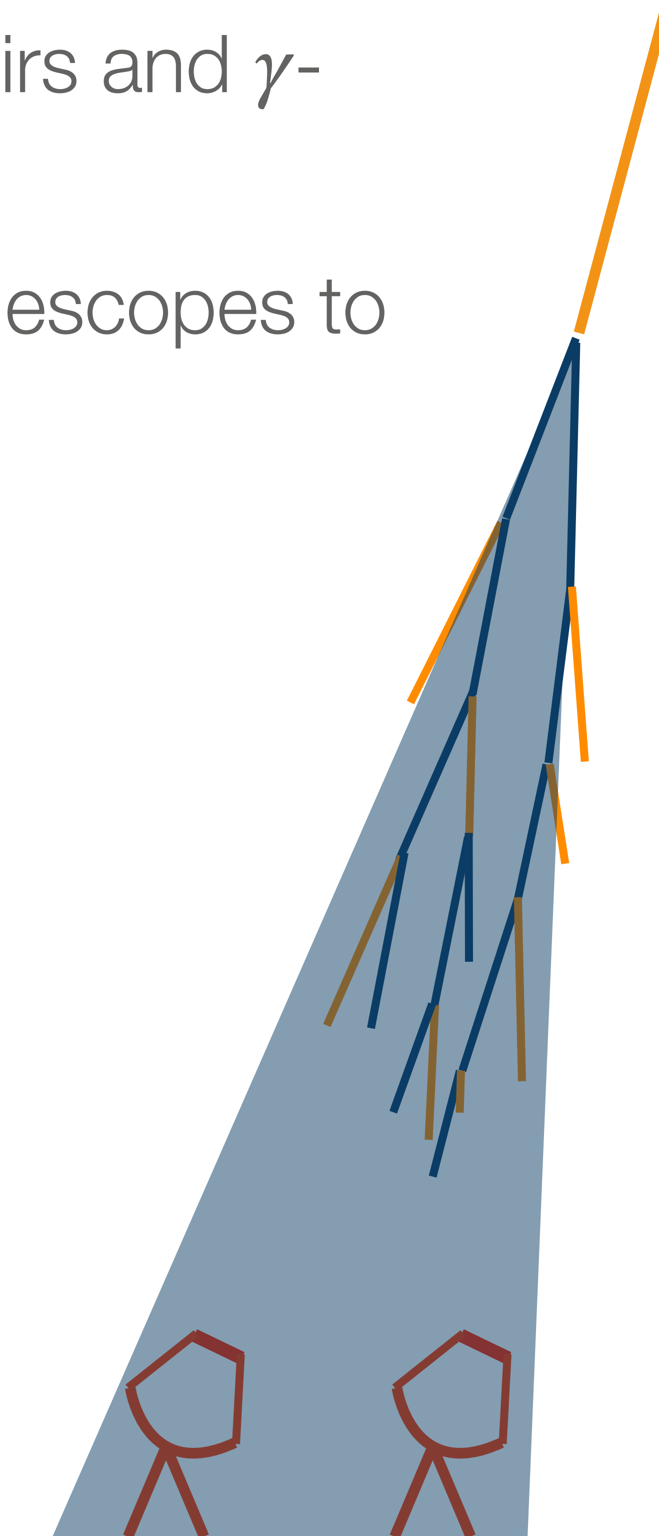
- Goal: Understand the “high-energy” universe via accelerated particles (called Cosmic Rays)
- Acceleration of Cosmic Rays often leads to emission of gamma-rays => Better identification of sources



H.E.S.S.
(High Energy Stereoscopic System)



- Ground-based measurement of cosmic gamma-rays
  - Primary γ-ray initiates cascade of secondary $e^{\pm}$ pairs and γ-rays in atmosphere
  - $e^{\pm}$ emit Cherenkov light - detectable by suitable telescopes to reconstruct energy and direction of primary γ-ray
- H.E.S.S.:
  - Array of Cherenkov telescopes in Namibia
  - γ-ray energies: 50 GeV - 100 TeV



Topic: Resolving Particle Acceleration in RX J1713.7-3946 with Advanced Gamma-Ray Imaging Methods

» Supervisors: Markus Holler

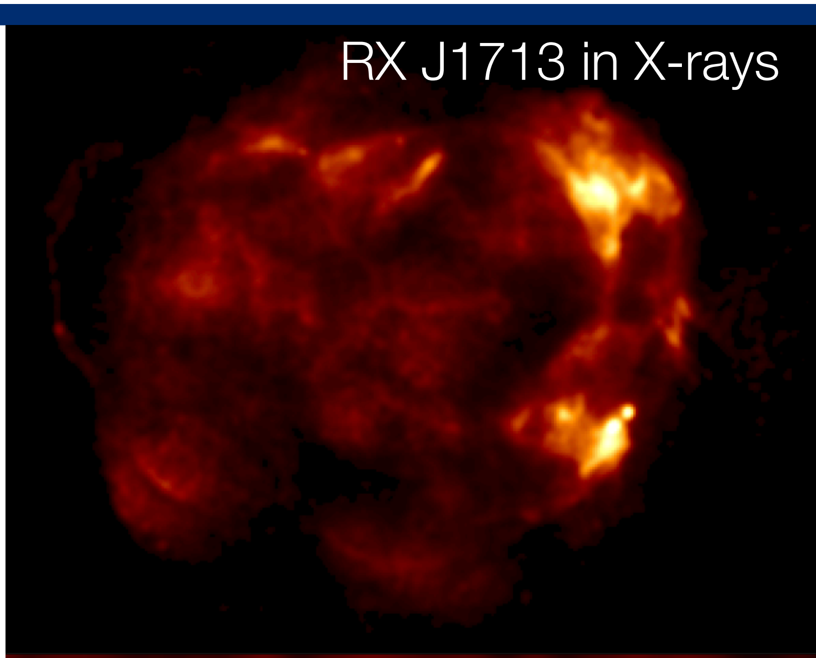
» Goal: Create a better-resolved γ-ray image of this supernova remnant by using adaptive Kernel Density Estimation (KDE)

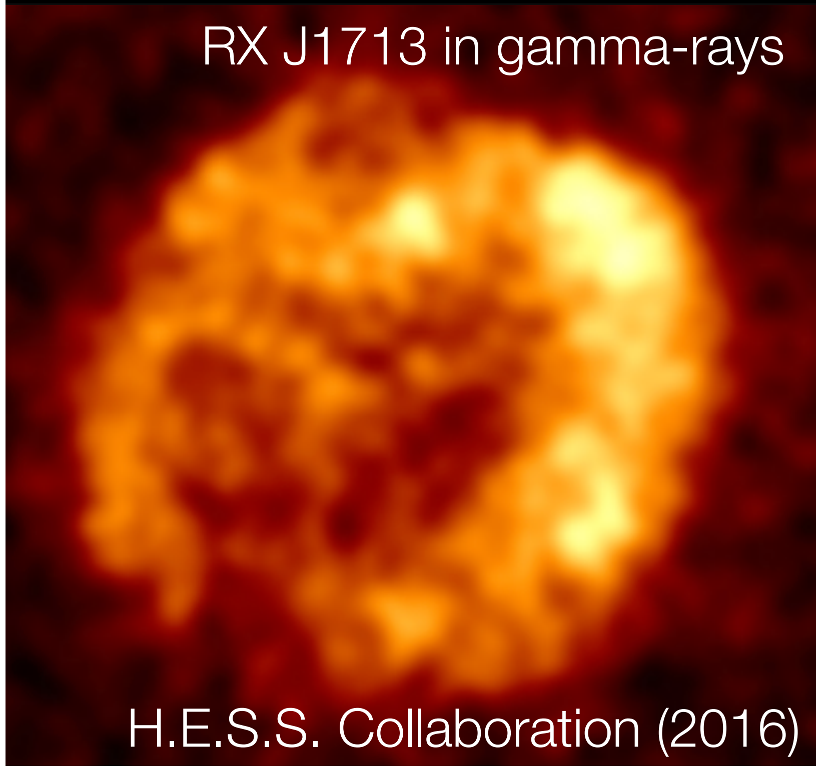
» You will:

- Work with H.E.S.S. data of RX J1713
- Try to correlate the X-ray and γ-ray emission

» Helpful prerequisites:

- Basic *python* or general programming knowledge
- Interest in analysis methods of γ-ray astronomy



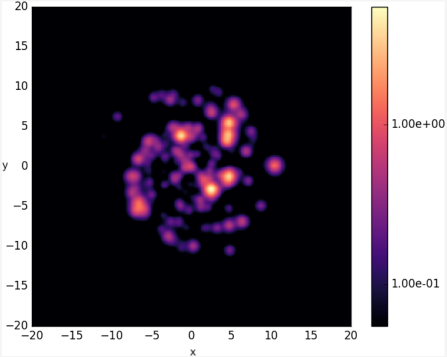


Thanks for Listening!

- Here just one topic presented, but if you’re interested in something specific let’s talk about it!

Simulation of Galactic CR Transport

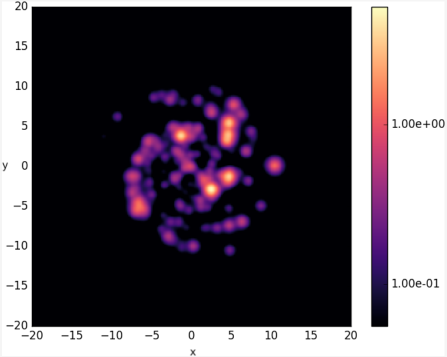
CR Distribution



(Thaler (2019))

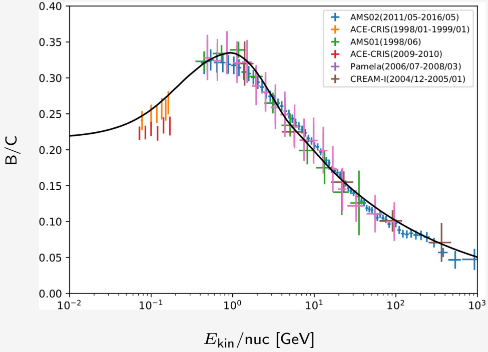
Simulation of Galactic CR Transport

CR Distribution



(Thaler (2019))

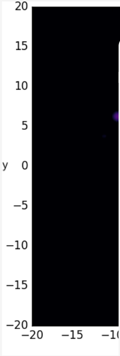
Simulated CR Spectra



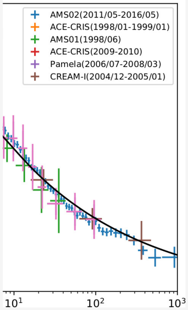
(Picard (2018))

Simulation of Galactic CR Transport

CR Distribution

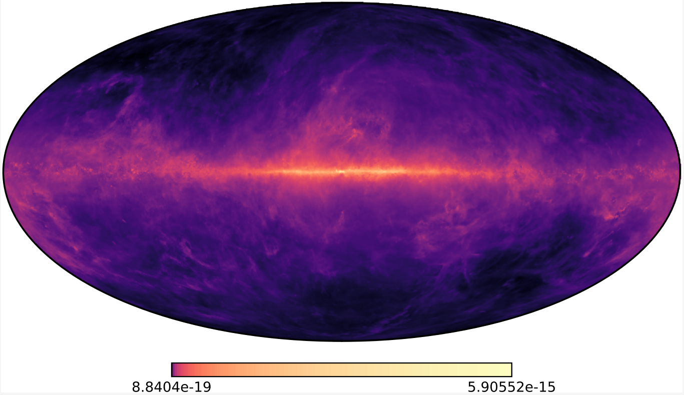


Simulated CR Spectra



(Picard (2018))

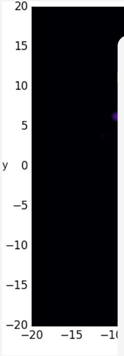
Predicted Diffuse Gamma-Ray Emission



(Thaler (2019))

Simulation of Galactic CR Transport

CR Distribution



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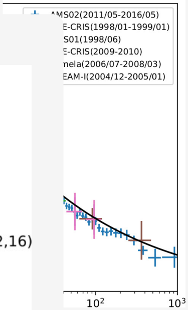

(Picard (2018))

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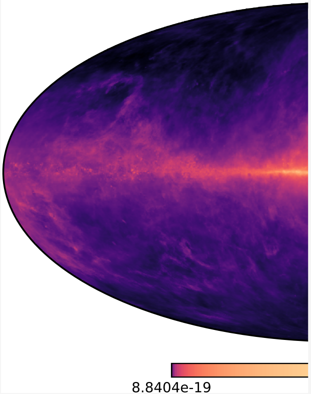
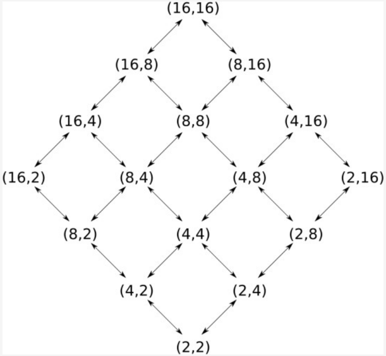


(Thaler (2019))

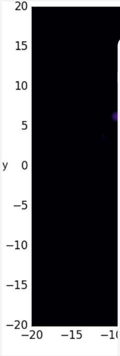
Numerics: Multigrid



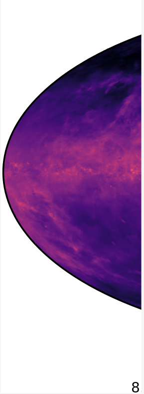
(Steinlechner (2021))

Simulation of Galactic CR Transport

CR Distribution



Predicted D



Inelastic interactions of cosmic rays with the interstellar medium in the Milky Way

Context: Astrophysical plasmas; Numerical Simulations; Instabilities

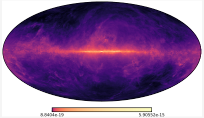
Supervisor: Anita Reimer & Ralf Kissmann

Abstract

If humans would have eyes sensitive to gamma rays, a bright band would be “visible” in the southern night sky. These gamma rays are partly produced in inelastic interactions of cosmic rays (i.e., mostly charged particles reaching relativistic velocities) with matter distributed mainly in the disk of our Galaxy. Recent data imply that the fraction of heavy cosmic ray nuclei changes with energy. Hence, a good understanding of inelastic nuclear interactions, typically implemented in simulation tools such as the PICARD code, is needed to understand the observed gamma-ray spectrum. The bachelor project consists of understanding inelastic nuclear interactions of Galactic cosmic rays with matter in general, and applied to the Milky Way. In particular, the goodness of the approximations for this process as implemented in the PICARD code shall be evaluated by comparing with the results of corresponding Monte-Carlo simulations using public event generators.

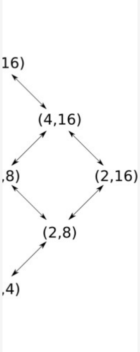
Helpful Skills

- Interest in nuclear physics reactions
- Interest in numerical modelling

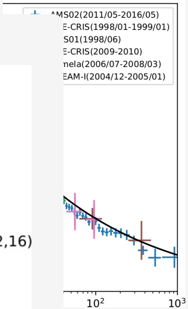


Numerical model of Galactic diffuse gamma-ray emission

ectra



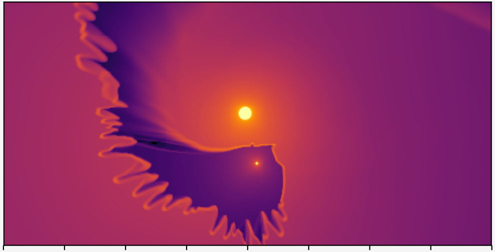
(Steinlechner (2021))



(PICARD (2018))

Simulation of Cosmic-Ray Sources

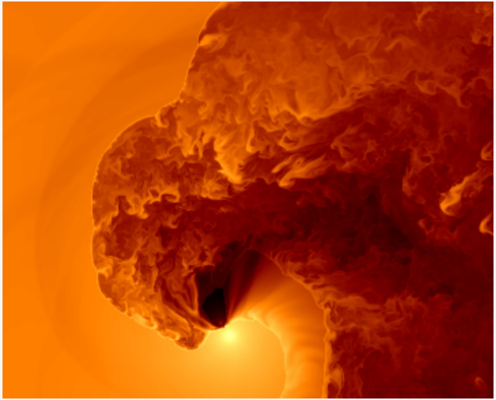
A Collinding-Wind Binary



(Kissmann (2019))

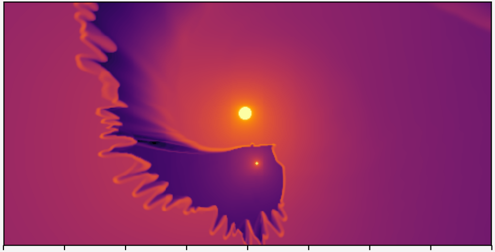
Simulation of Cosmic-Ray Sources

Simulated Gamma-Ray Binary



(Huber & Kissmann (2021))

A Collinding-Wind Binary



(Kissmann (2019))

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Simulated Gamma-Ray Binary

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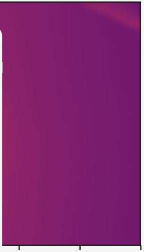
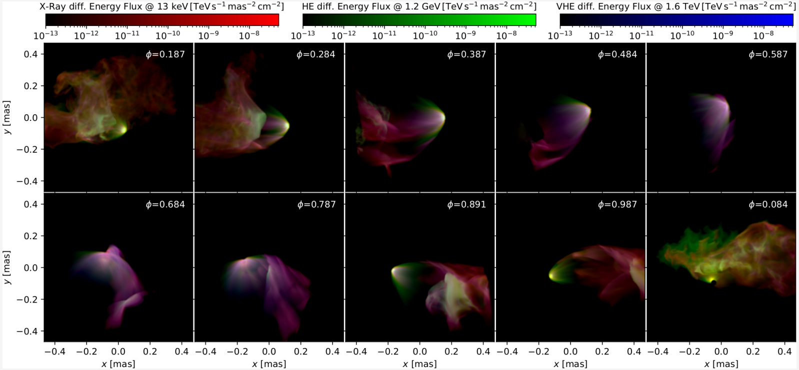


(Kissmann (2019))

Related High-Energy Emission



(Huber, Kissmann & Reimer (2021))

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Simulated Gamma-Ray Binary

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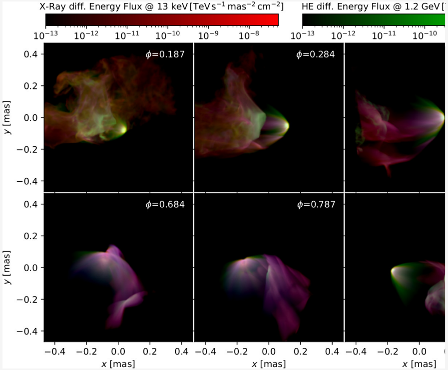

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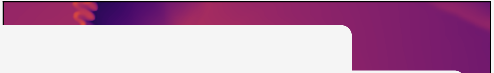
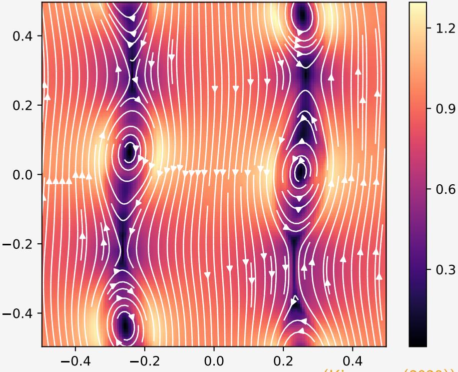


19))

Numerics: MHD / Relativistic HD



(Kissmann (2020))

Simulation of Cosmic-Ray Sources

Simulated Gamma-Ray Binary

Non-Linear Particle Acceleration

Context: Astrophysical plasmas; Numerical Simulations; Instabilities

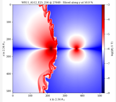
Supervisor: Ralf Kissmann

Abstract

An important acceleration process for cosmic rays is Fermi-I acceleration, where particles are scattered back and forth over a shock wave. On average they gain energy in each of these shock crossings. This process directly follows when solving the cosmic-ray transport equation either analytically or as in this case with the computer. What is often neglected, however, is that the energy gain of the particles also implies an energy loss of the gas. To consider this effect is the main aim of this bachelor project. For this, the interested candidate will first set up a one-dimensional simulation of a shock wave using the Cronos code. Next, the particle-transport equation will be solved in the environment of the modelled shock wave. Finally, the energy density of the accelerated cosmic-ray particles is to be computed from the simulation and then added as an external pressure to the gas simulation. By this, we will be able to judge the importance of the effect of this back reaction.

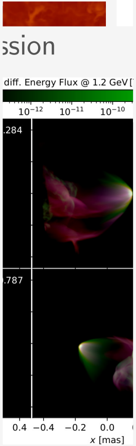
Helpful Skills

- Basic programming knowledge
- Interest in fluid mechanics and numerical simulations



Potentially particle-accelerating shocks in colloding-wind binary simulations

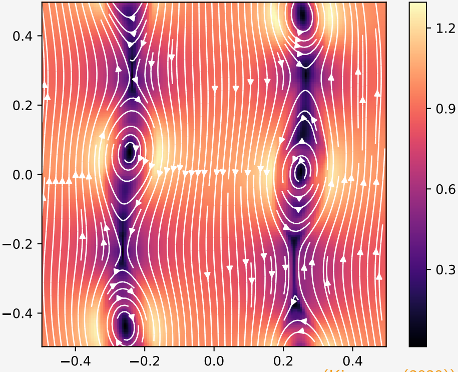
ssion



A Collinding-Wind Binary

19))

Numerics: MHD / Relativistic HD



(Kissmann (2020))

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Simulated Gamma-Ray Binary

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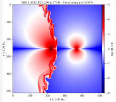
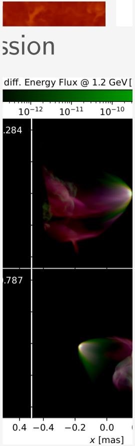


Potentially particle-accelerating shocks in colloding-wind binary simulations



A Collinding-Wind Binary

Numerical Solution of Advection for Power-Laws

Context: Astrophysical plasmas; Numerical Simulations; Instabilities

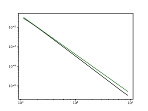
Supervisor: Ralf Kissmann

Abstract

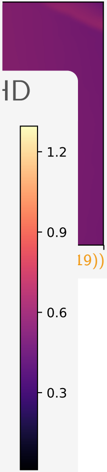
When modelling Fermi acceleration, gains and losses of energy can be viewed as advection in momentum. Therefore, in our numerical model of this acceleration process, we use a so-called semi-Lagrangian solver to model energy gains and losses. This semi-Lagrangian solver however, is optimised for modelling advection of functions that can be described as a low-order polynomial. For Fermi acceleration, however, we expect energy dependencies in the form of a power law. In this thesis, the interested candidate will compare results of a numerical model of Fermi acceleration with the analytical solution, to compute a measure of the quality of the numerical solution. Then, parts of the solver will be adapted to try to improve the numerical solution, where we aim for an improved accuracy or an improved efficiency of the numerical scheme.

Helpful Skills

- Basic programming knowledge
- Interest in numerical methods



Comparison of numerical and analytical solution of Fermi acceleration.



Institute for Astro- and Particle Physics
Extragalactic Astrophysics

Research group Extragalactic Astrophysics

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Bachelor thesis topics 2024

Main research field: Observational cosmology

The present-day energy budget of the Universe:

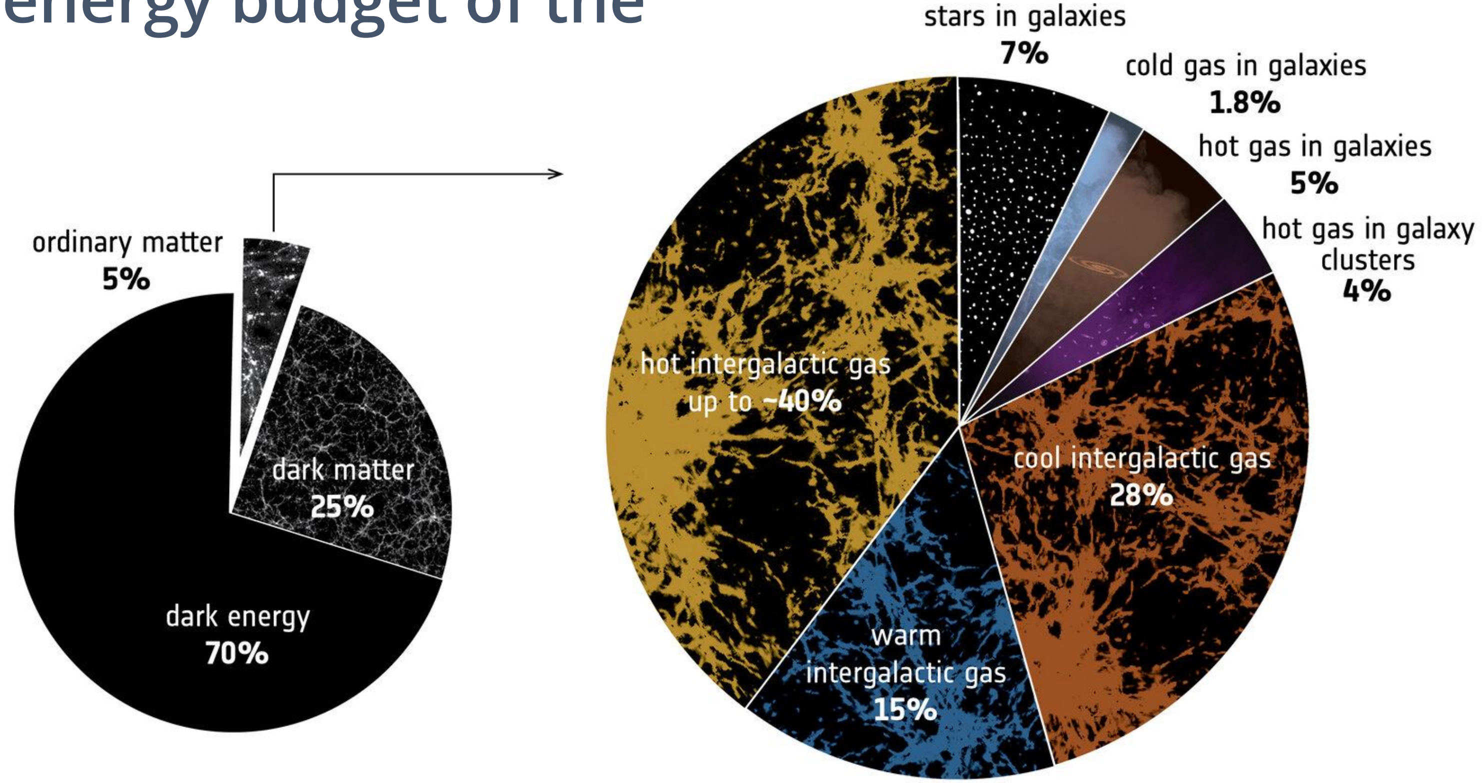
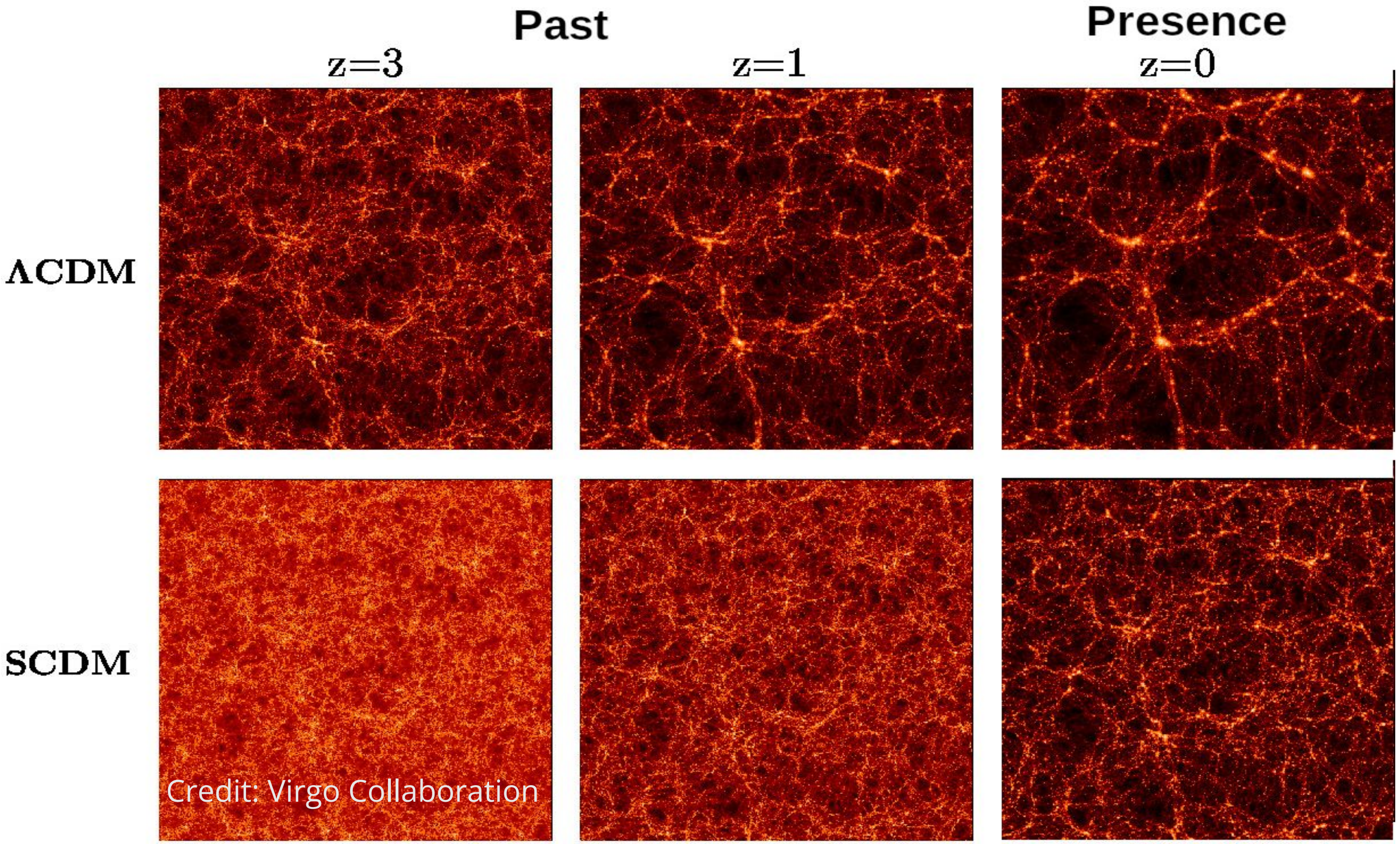


Image Credit: ESA

Main focus of the group: Probing cosmology via …

… the growth of structure

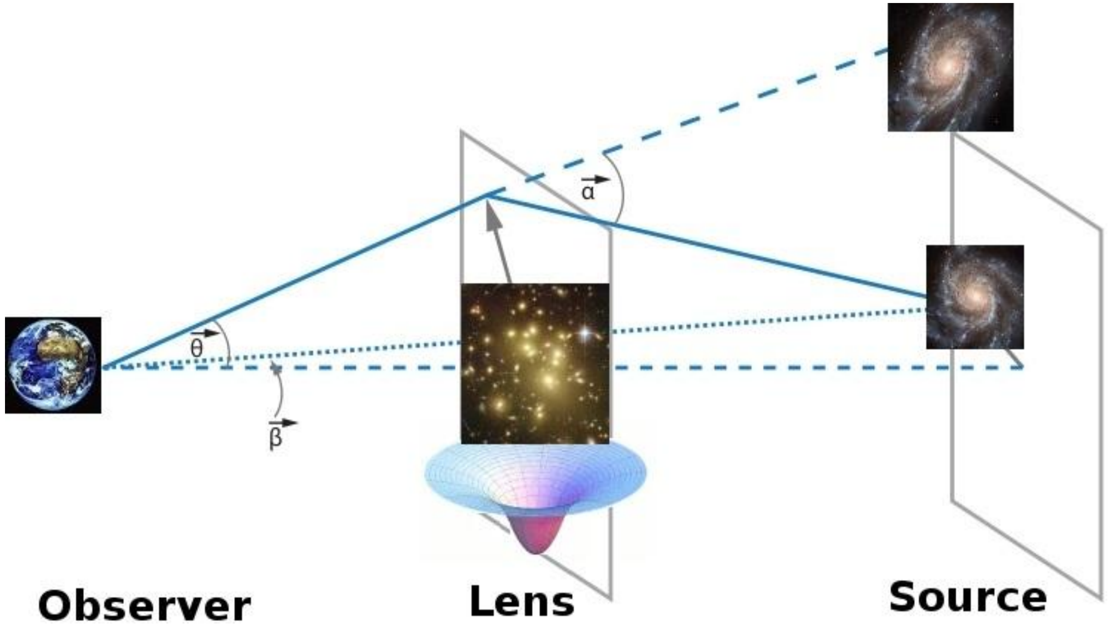
Dark matter distributions in cosmological simulations



Main focus of the group: Probing cosmology via ...

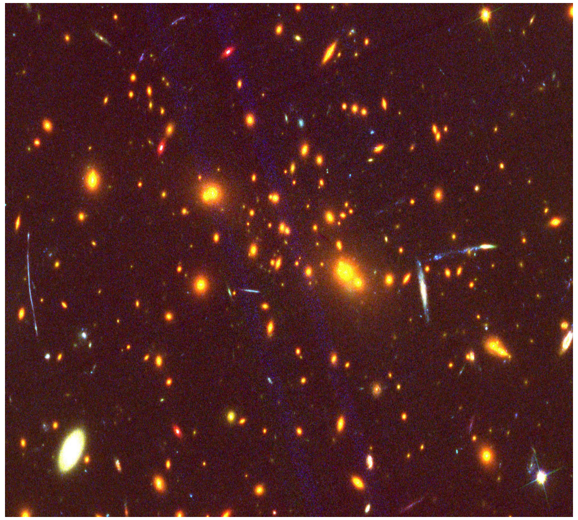
... the growth of structure

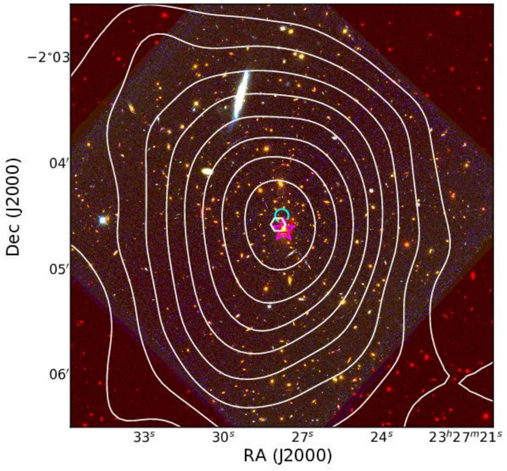
+ weak gravitational lensing



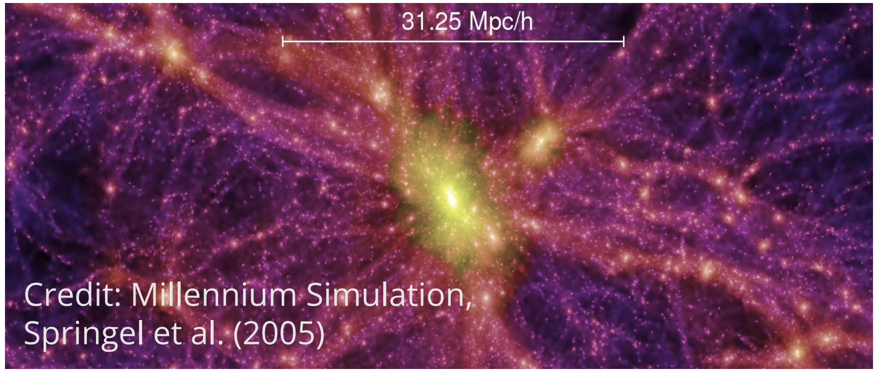
Credit: Treu 2011, NASA, Meteosat, C. Mc Allen

Galaxy cluster RCS2327-03 + lensing mass reconstruction



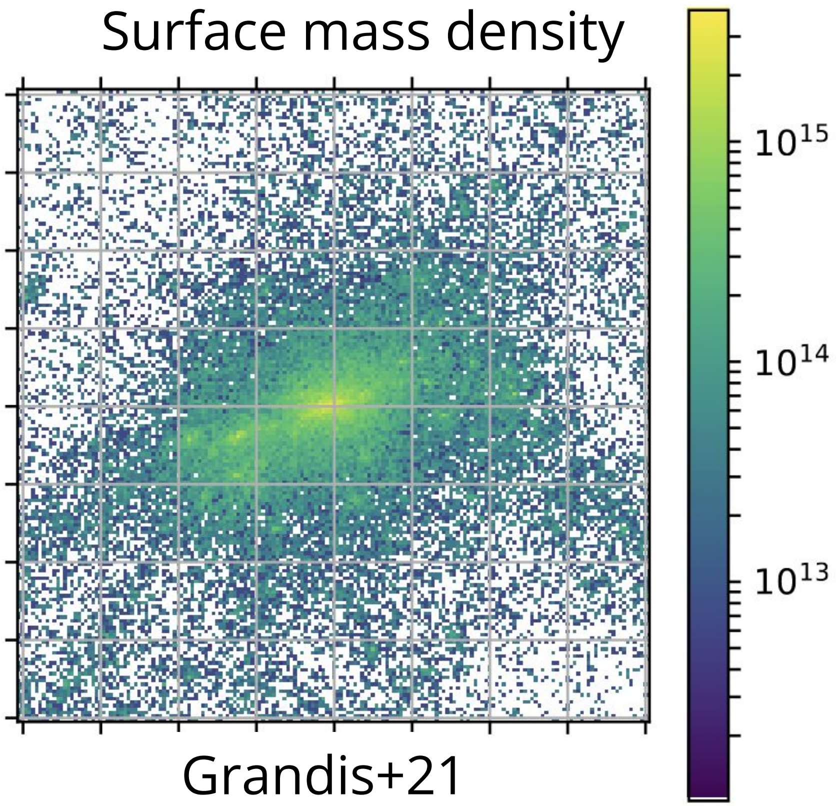


Credit: ESO / NASA / ESA / Schrabback et al. (2018b) A&A 610, A85



Credit: Millennium Simulation, Springel et al. (2005)

Topic 1: Modeling the anisotropy in cluster weak lensing maps

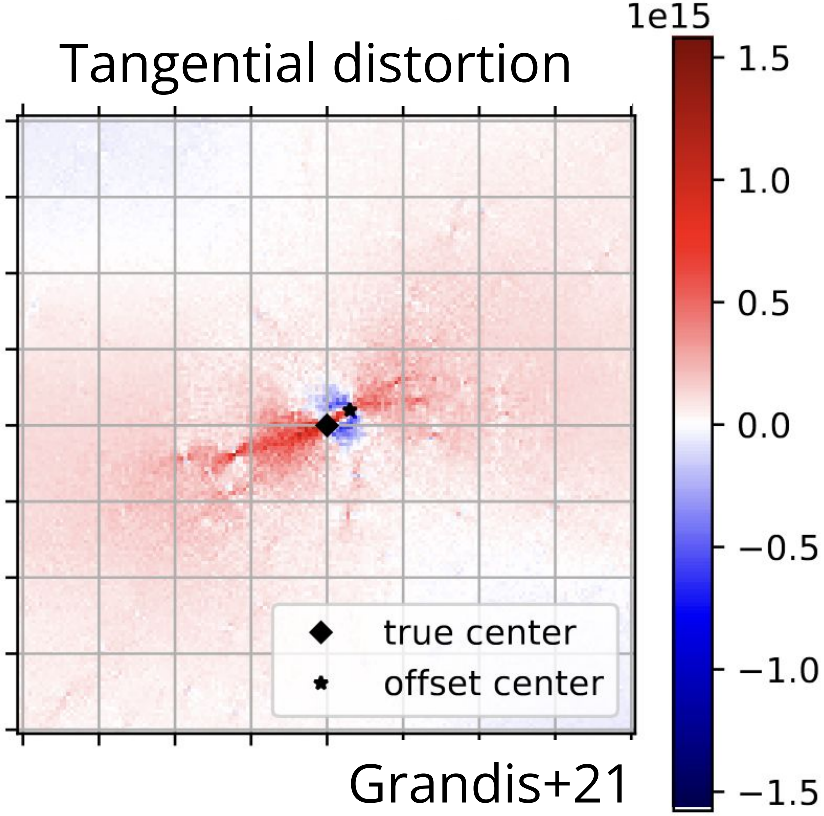


Grandis+21

Tangential shear profiles around clusters are used to understand the **mass scale** of cluster samples. **Anisotropic information** helps to understand secondary effects like **mis-centering and ellipticity**.

In this project you will further develop methods to **extract information about the anisotropy of cluster weak lensing signals** and estimate if the resulting signal can be measured in real data.

Requirements: some python experience, solid knowledge of analysis, astrophysics welcome



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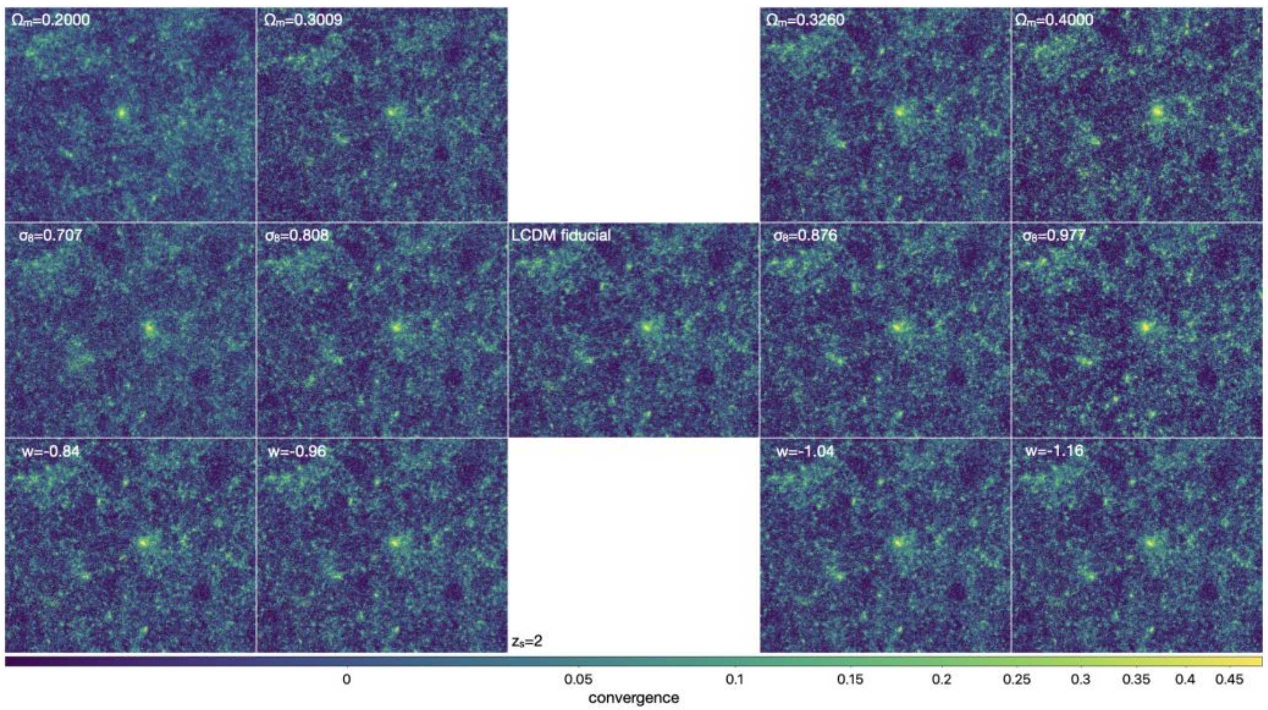
Topic 2: Cosmological information from weak lensing



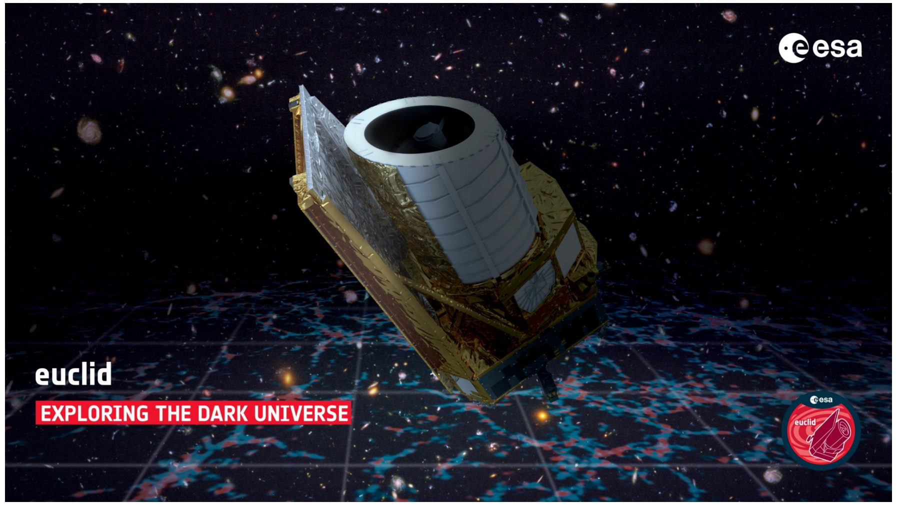
Projected dark matter distribution from simulations with different cosmologies

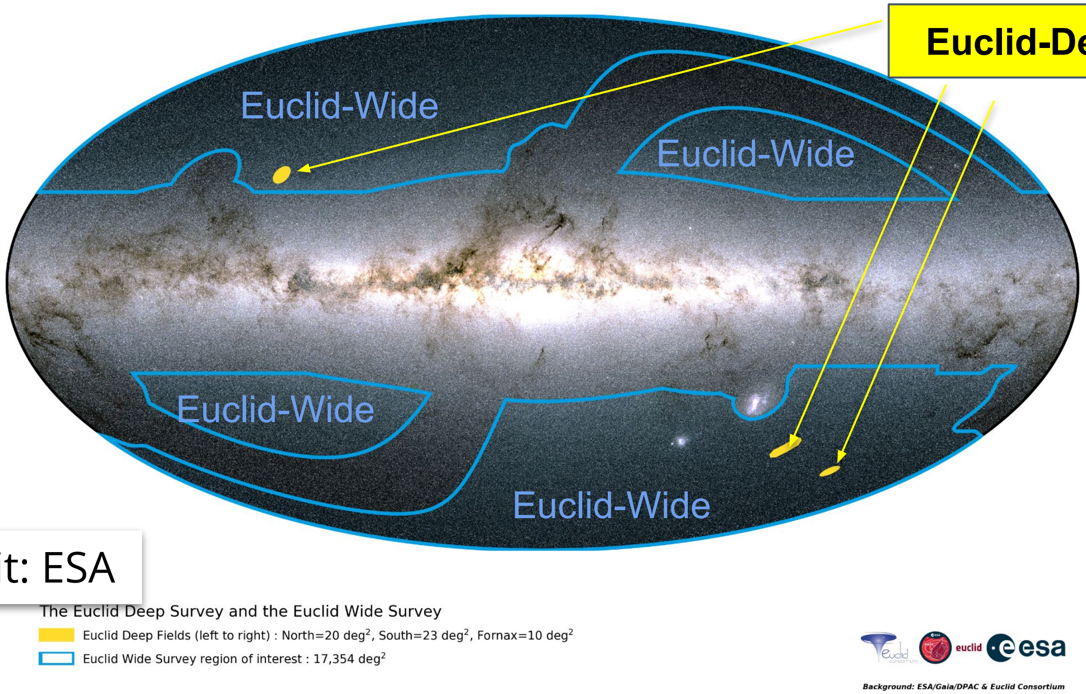
We usually extract cosmology from weak lensing by measuring **second-order correlations**, i.e., by comparing the shapes of **pairs** of galaxies at a certain distance. We know we can get **more information by looking at triplets** of galaxies. **But what about quadruplets?**

In this project you will use dark matter distributions from cosmological simulations to test if the 4th-order statistics can be predicted from 2nd and 3rd order statistics or not. Deviations show that information could be gained!

Image credit: Euclid Collaboration: Ajani et al. (2023), A&A 675, A120

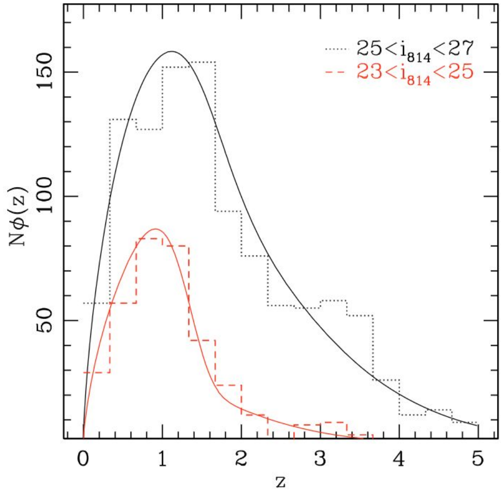
Topic 3: Prospects for weak lensing in *Euclid's* Deep Survey





Credit: ESA

The Euclid-Deep Survey will have a much higher density of high-redshift sources compared to Euclid-Wide, but cover a much smaller sky area



Galaxy redshift distribution in two magnitude bins in Hubble deep field data (Schrabback et al. 2010)

Questions to answer in this Bachelor thesis project:

- Can Euclid-Deep improve weak lensing measurements of the masses of high-redshift galaxies & galaxy groups?
- How robustly can we select high-redshift background galaxies in Euclid-Deep and Euclid-Wide data?