

Country report

**Astronomy in Vietnam:
Recent developments**

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The growing importance of astrophysics in world scientific research needs to be properly acknowledged in Vietnam: currently, our PhD and Master students must graduate in other fields such as nuclear or atomic physics.

Names such as Jane Luu, Trinh Xuan Thuan or Nguyen Quang Rieu, of Vietnamese-born astrophysicists having left the country half a century or so ago, are well known.

The latter, a radio astronomer working in France, has played an important role in promoting astrophysics in Vietnam and inspiring and guiding the main current actors of astrophysics research in the country:

Dinh Van Trung at Hanoi's Institute of Physics, Phan Bao Ngoc at the Viet Nam International University in Ho Chi Minh City and the team of the Department of Astrophysics in the Viet Nam Space Centre in Ha Noi

Prof. Dinh Van Trung

Head of the Institute of Physics of the
Vietnam Academy of Sciences and Technology.



Professor Dinh Van Trung was trained in France and spent several years in Taiwan with Academia Sinica before returning to Viet Nam. With expertise in radio astronomy and molecular gas, he publishes his research work together with members of international collaborations and has initiated several hardware efforts at IOP (LIDAR, mirror construction, etc...)

Authors		arXiv	First author	Journal	Topic
VN	VN				
1	2	1710.05543	D.V. Trung	ApJ 851(2017)65D	IRC+10420
1	5	1710.06186	J. Lim	ApJ 850(2017)31L	NGC1275
1	3	1807.10205	J.H. He	ApJ 845(2017)38H	IRC+10216
1	5	-	S. Matsushita	PKAS 30(2015)349M	AGN M51
1	5	1410.7863	S. Matsushita	ApJ 799(2015)26M	M51 NGC5194
1	19	1407.3235	L.P. David	ApJ 792(2014)94D	NGC 5044
1	19	1404.7667	S. Muller	A&A 566A(2014)112M	PKS-1830.211
1	13	-	S. Muller	A&A 566(2014)L6	5 PKS-1830.211

Prof. Phan Bao Ngoc



Like Professor Dinh Van Trung, Associate Professor Phan Bao Ngoc was trained in France and worked as a postdoc in Taiwan's Academia Sinica. He is a world expert in the field of Brown Dwarfs, to which he made important contributions. He currently leads the Physics Department of the VNU International University in HCMC.

Authors		arXiv	First author	Journal	Topic
VN	VN				
2	5	1612.09370	P.B. Ngoc	A&A 600A(2017)19P	Late-M dwarfs
2	0	1602.06357	C. Dang-Duc	A&A 588(2016)L2	Taurus
2	0	1602.06357	C. Dang-Duc	A&A 588L(2016)	Taurus
2	3	1408.4506	P.B. Ngoc	ApJ 795(2014)70P	Gas/substellar
1	3	1403.1926	P.B. Ngoc	A&A564(2014)A32	J041757

DAP/VNSC

P.N. Diep, P.T.T. Nhung, P.Tuan-Anh, D.T. Hoai, N.T. Phuong, T.T. Thai, P. Darriulat

For some ten years, the main interest of the team was the study of very high energy extragalactic cosmic rays in collaboration with the Pierre Auger Observatory in Argentina. Three of us have made our PhD theses in this field. We made significant contributions to the very successful achievements of this program.

We also developed and operated detectors of our own at home, with which we measured the flux and asymmetry of atmospheric cosmic neutrinos on the geomagnetic equator [Nuclear Physics B, 627(2002)29, 661(2003)302 and 678(2004)3].

DAP/VNSC

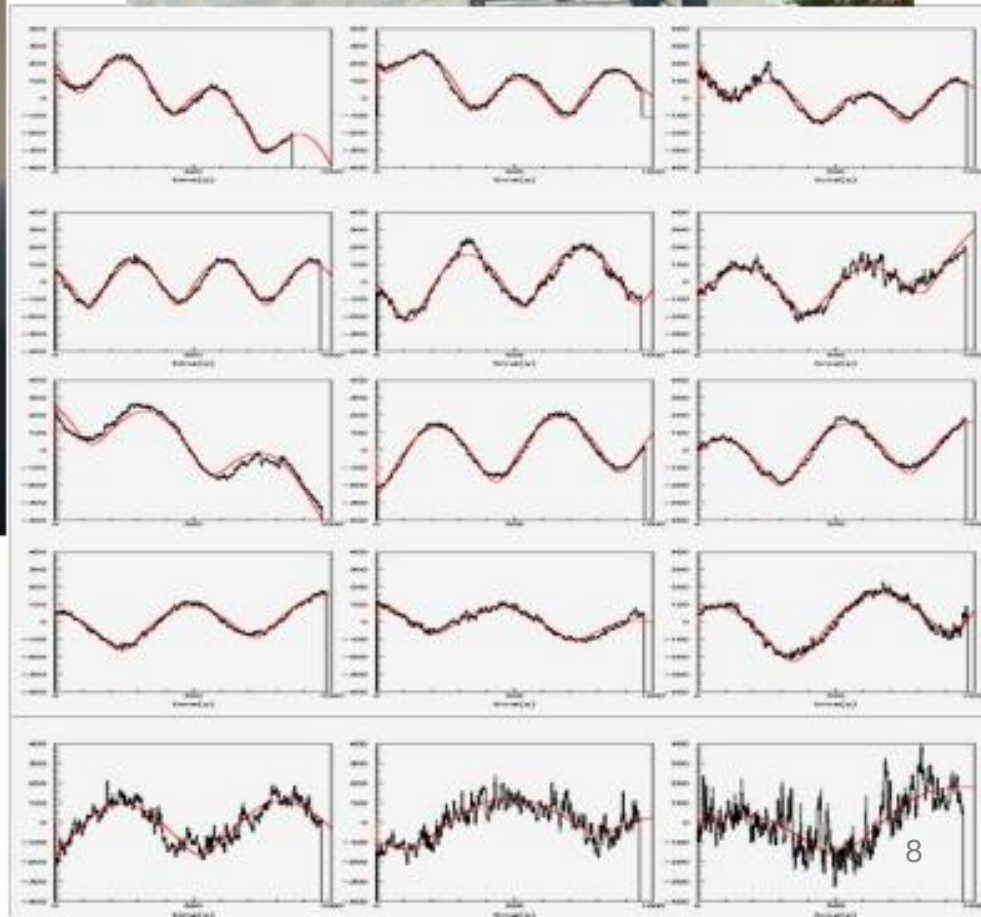
Over ten years ago, we decided to switch our main interest from cosmic rays to radio astronomy.

We were motivated by the progress made by the field in recent years, by the availability of archival ALMA observations soon after they were taken, by the better match to the constraints attached to training students and to building a research team in Viet Nam.

We were encouraged by Professor Nguyen Quang Rieu who had given Viet Nam a Yagi interferometer, which I could use for my master work on solar observations (the first Vietnamese master thesis in astrophysics).



Professor
Nguyen Quang Rieu



For over ten years, we have been doing research in
Astrophysics: Stellar Physics and Early Universe

- On our own using ALMA archival data
- In collaboration with Paris (T. Le Bertre and J.M. Winters) on evolved stars (ALMA and IRAM)
- In collaboration with Bordeaux (A. Dutrey and S. Guilloteau) on proto-stars (ALMA and IRAM)
- In collaboration with Marseille (Roser Pello and Johan Richard) on high-z galaxies (VLT/MUSE)
- In collaboration with KASI (Hoang Chi Thiem) and with EAO (JCMT programs) on roles of magnetic fields and dust in star formation and stellar feedback

Author	VN	nonVN	Reference	Keywords
Trung, D.V.	1	5	2015 PKAS 30 349M	Gas+jet AGN M51
Trung, D.V.	1	5	2015 ApJ 799 26M	Gas+jet AGN M51
Trung, D.V.	1	19	2014 ApJ 792 94D	Gas NGC 5044
Phan-Bao, N.	2	0	2016 A&A 588L 2D	Low mass objects Taurus
Phan-Bao, N.	2	2	2015 PKAS 30 83P	Outflows & low mass
Phan-Bao, N.	1	15	*2015 AAS #225	HST nearUV flare spectra
Phan-Bao, N.	2	3	2014 ApJ 795 70P	Outflows substellar
Phan-Bao, N.	1	3	2014 A&A 564 A32	SMA/SSTB213 J041757
Lan, N.Q.	3	0	2016 Still a draft	Spinning dust
Lan, N.Q.	1	3	2014 PhRevD92 123514	Pre-inflation fluctuations
Lan, N.Q.	1	5	2016 ApJ 819	Betelgeuse
Lan, N.Q.	1	3	2016	Binary neutron stars
Lan, N.Q.	3	1	2015 PKAS 30 521L	Galaxies local group
Lan, N.Q.	1	2	2015 PKAS 30 309M	Preinflation & dark flow
Lan, N.Q.	1	7	2014 MPLA 2930012M	Nucleosynthesis local group
Lan, N.Q.	2	1	2015 PKAS 30 315L	Late decaying dark matter
DAP/VNSC	7	0	MNRAS submitted	RX J0911
DAP/VNSC	7	0	MNRAS accepted	Protostar L1527/ALMA
DAP/VNSC	7	0	2016 MNRAS acc.	Deprojection methodology
DAP/VNSC	7	0	2016 MNRAS acc.	Mira Ceti/ALMA
DAP/VNSC	7	3	*2016 ASPC 502 61D	CSE's AGB stars CO/HI
DAP/VNSC	7	0	2016 RAA	Pi Gru/ALMA
DAP/VNSC	7	0	2016 RAA	W Aql/CO
DAP/VNSC	7	2	2015 A&A	EP Aqr/CO
DAP/VNSC	3	3	*2015 ASPC497 133N	RS Cnc CO sym.
DAP/VNSC	2	5	*2015 ASPC497 119H	RS Cnc CO+HI
DAP/VNSC	3	3	2015 RAA 15 713N	RS Cnc asymmetry
			2015 MNRAS 449	

Publications 2014-2017
VNSC/DAP: 16 ISI
 (with one of us as first author, and only 20% of other co-authors)
 (*) for conference proceedings

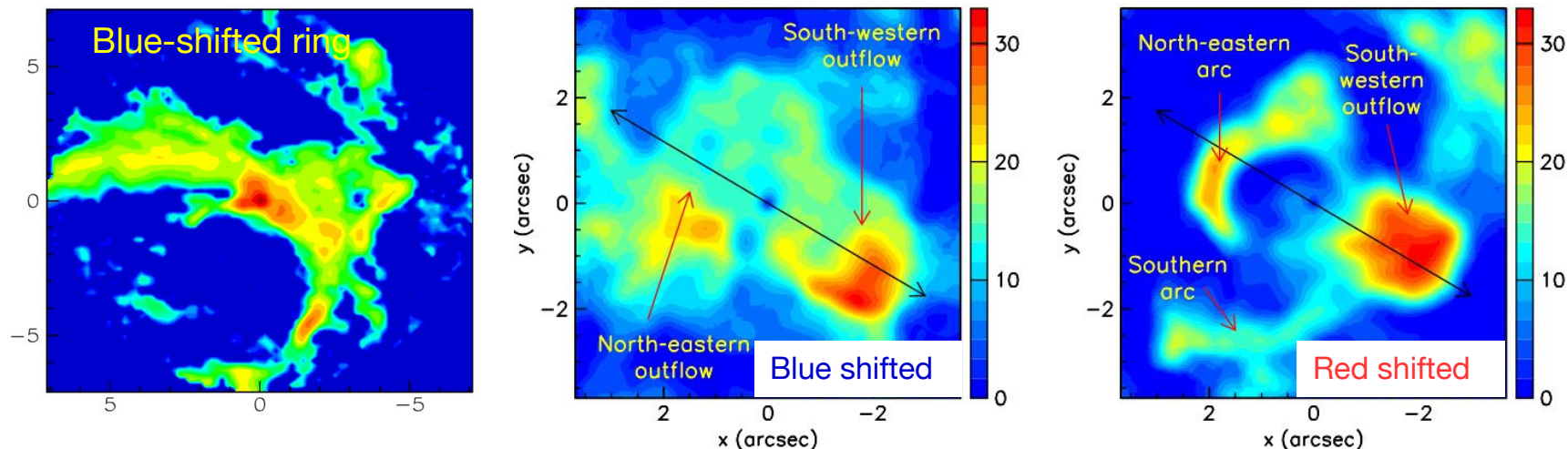
Publications 2017-2019
 Phan-Bao, Ngoc: 1 ISI
 Trung, D.V.: 1 ISI
 VNSC/VAST DAP: 11 ISI + 3
 National Publications

Publications 2020-2022
 Phan-Bao, Ngoc: 1 ISI
 VNSC/VAST DAP: 22 ISI + 3
 National Publications

See more at:
<https://dap.vnsc.org.vn/bibliography/scientific-publications>

Complexity of CSEs of AGB stars

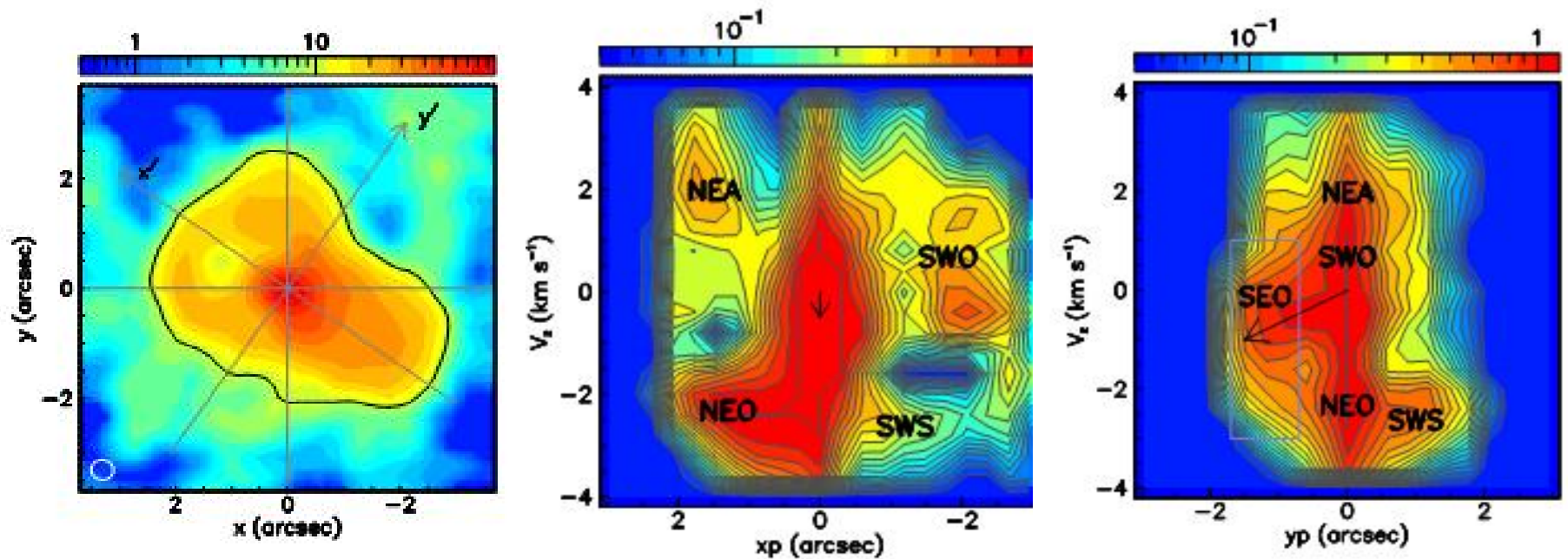
Example of Mira Ceti



A blue shifted ring is expanding radially at a velocity of <2 km/s. It was emitted a few centuries ago together with other red-shifted fragments.

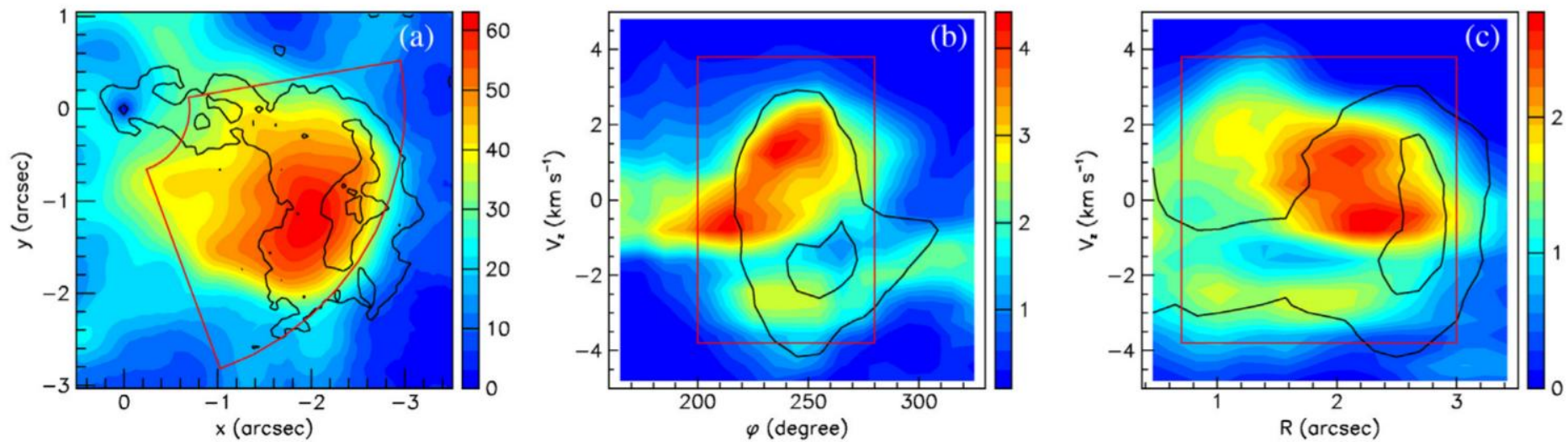
A slightly red shifted south-western outflow covers a broad solid angle and expands radially at a rate of $5-10$ kms $^{-1}$; a north-eastern outflow consists of two arcs, both blue-shifted.

Mira Ceti: an example of complexity



Rotated coordinates give evidence for detached fragments; typical mass loss rates are evaluated at the level of a few 10^{-8} solar masses per year for each individual fragment.

Mira Ceti: unexpected complication

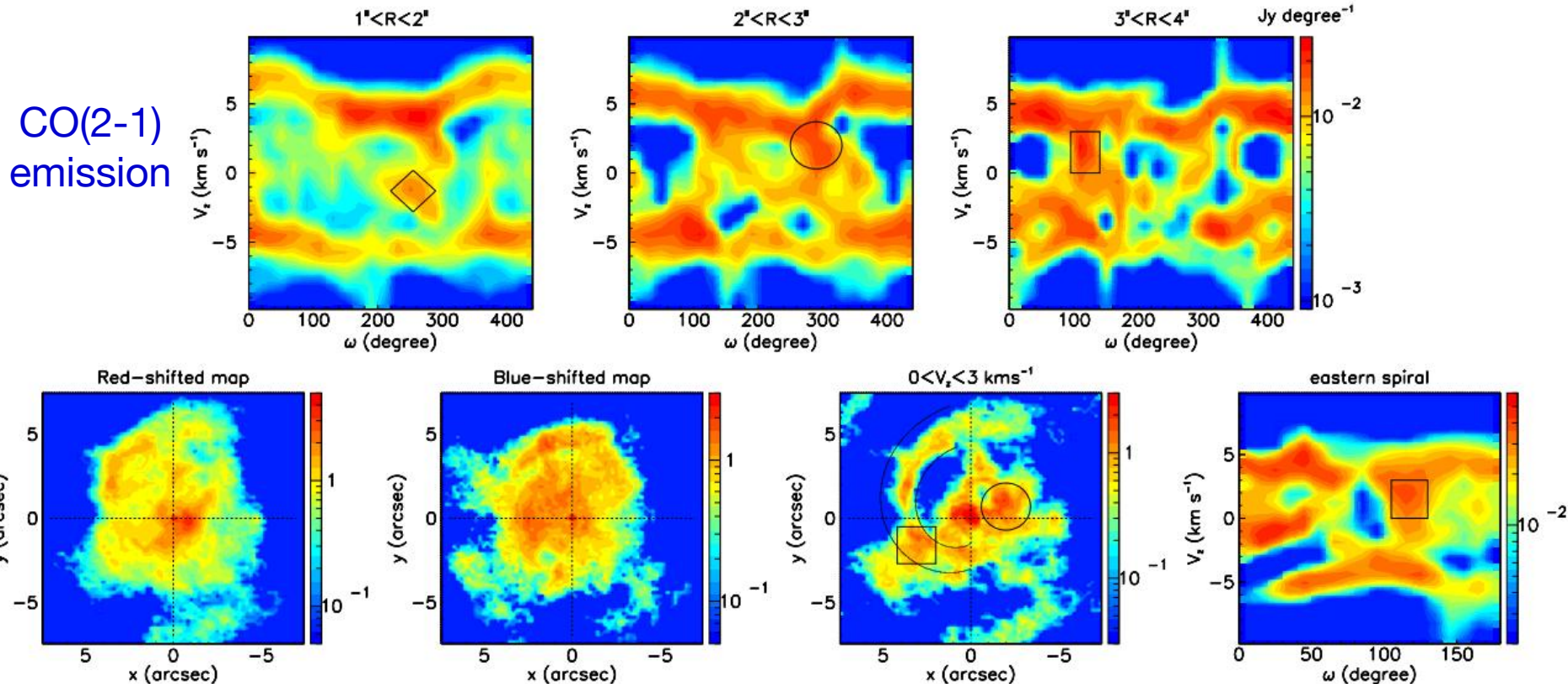


Apart from the south-western quadrant, SiO emission is absent, a result of the low mass-loss rate and of the strong photo-dissociation by interstellar UV radiation.

In the SW quadrant SiO and CO emissions are anti-correlated \rightarrow mass ejection occurred in 2003 and was accompanied by an X-ray burst and probable magnetic flare.

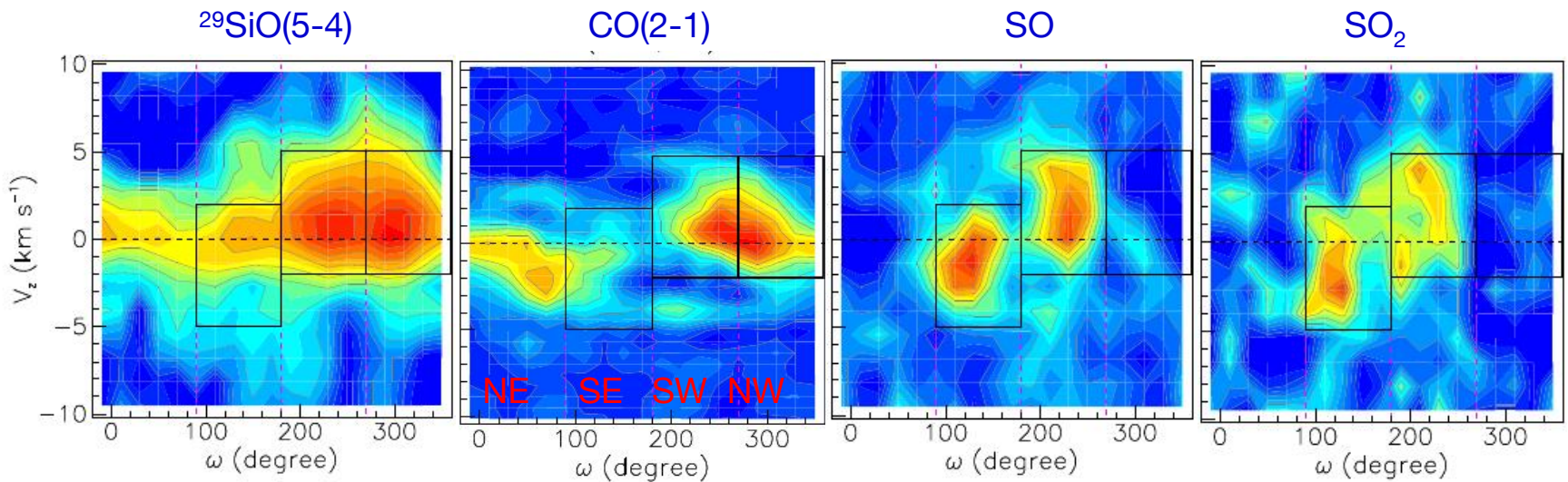
R Leo: episodic and patchy mass ejections

At large distances, the CSE is very patchy in morpho-kinematics and reveals an episode of enhanced mass loss, several centuries ago, that produced a broad expanding shell of mean radius ~ 6 arcsec and mean radial expansion velocity $\sim 5.5 \text{ km s}^{-1}$.



R Leo: episodic and patchy mass ejections

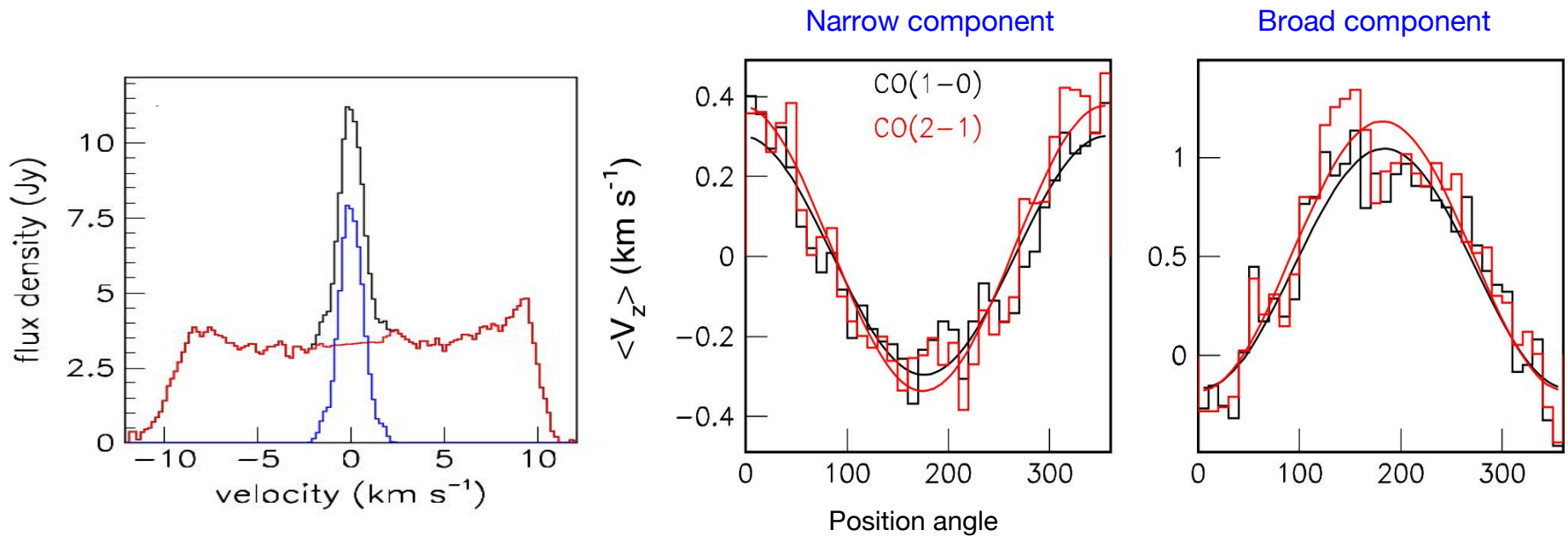
Within 30 au from the centre of the star, evidence is found for distant gas outflows covering broad solid angles in the SE, SW, NW quadrants suggesting significant contribution of the convective cell granulation in defining the pattern of mass ejection.



Bipolar outflow and expanding equatorial density enhancement

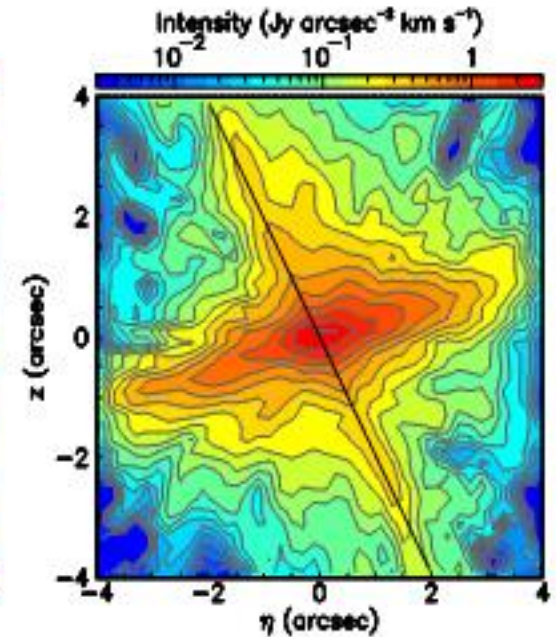
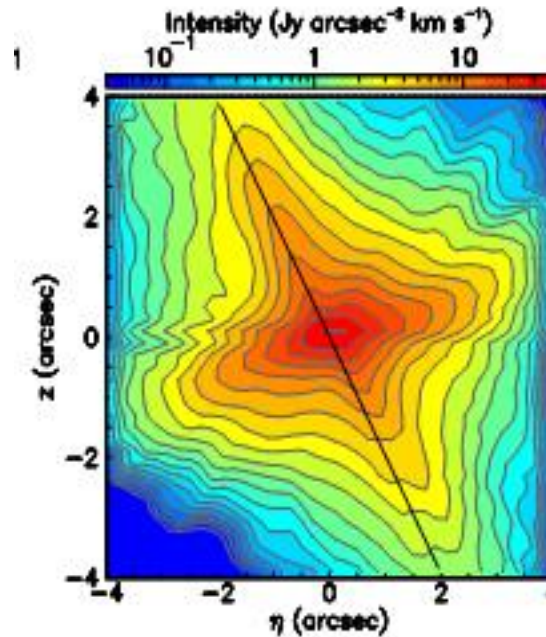
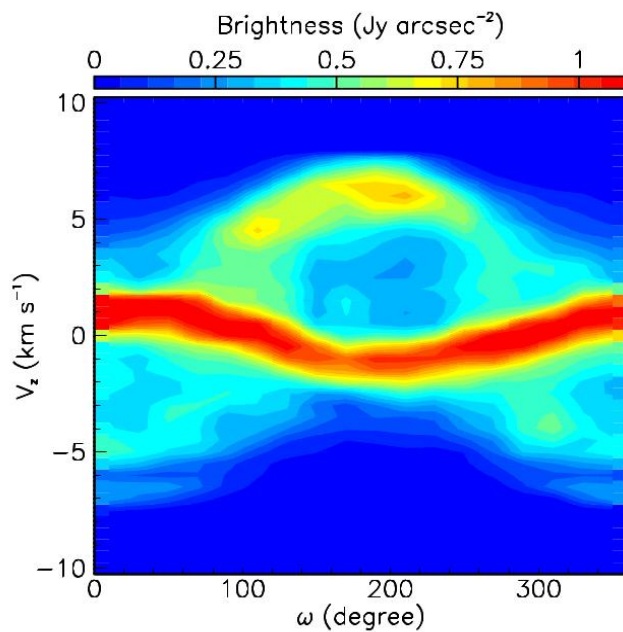
The CSEs of RS Cnc and EP Aqr display very similar morpho-kinematics, in the form of a slowly expanding equatorial density enhancement and of a pair of faster bipolar outflows.

EP Aqr



Bipolar outflow and expanding equatorial density enhancement

RS Cnc



The symmetry axis of EP Aqr is nearly on the line of sight while that of RS Cnc is at $\sim 40^\circ$ to the line of sight

Jan Martin, Hoai, Wong et al. 2022 (A&A)

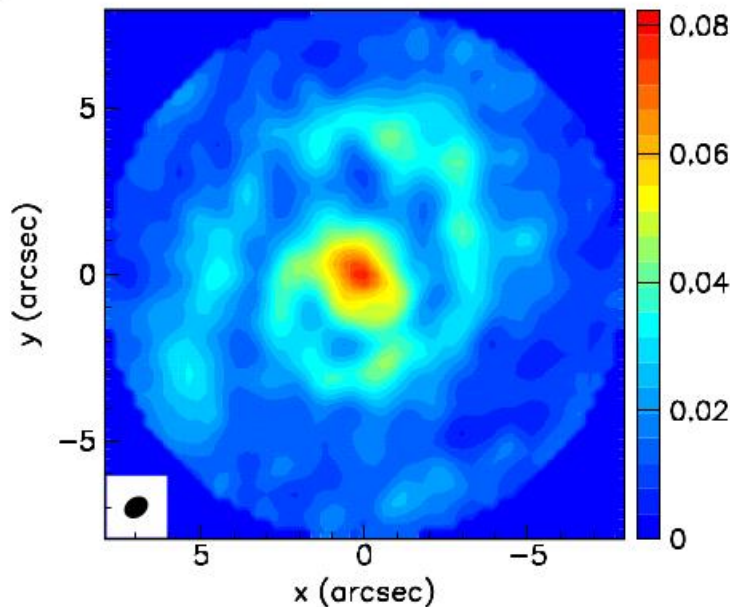
EP Aqr: equatorial enhancement

Both CO(1-0) and CO(2-1) emissions of the disc display density fluctuations, at the level of $\sim\pm 36\%$, in the form of a spiral.

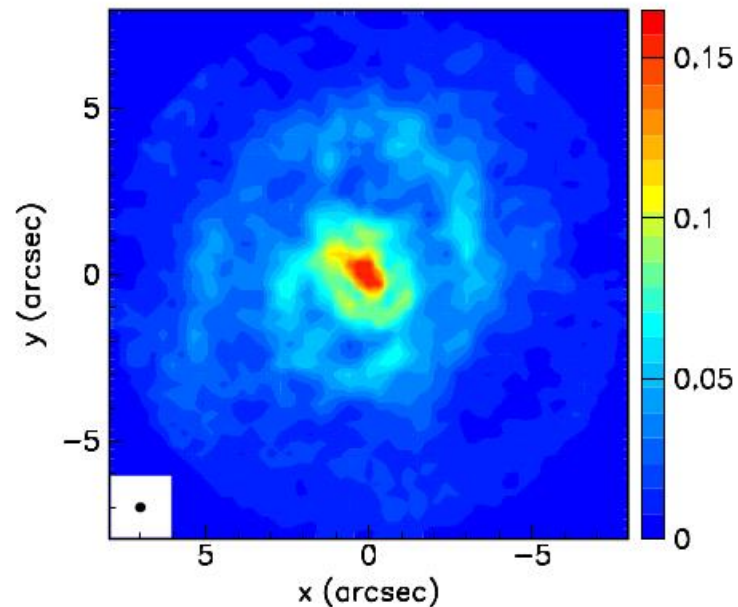
It was first observed by Homan et al. who interpreted it as the wake of a hidden companion.

The equatorial Doppler velocity displays radial modulation of very low amplitude, $\sim 0.2 \text{ km s}^{-1}$, and a period of $\sim 3.8 \text{ arcsec}$.

CO(1-0)



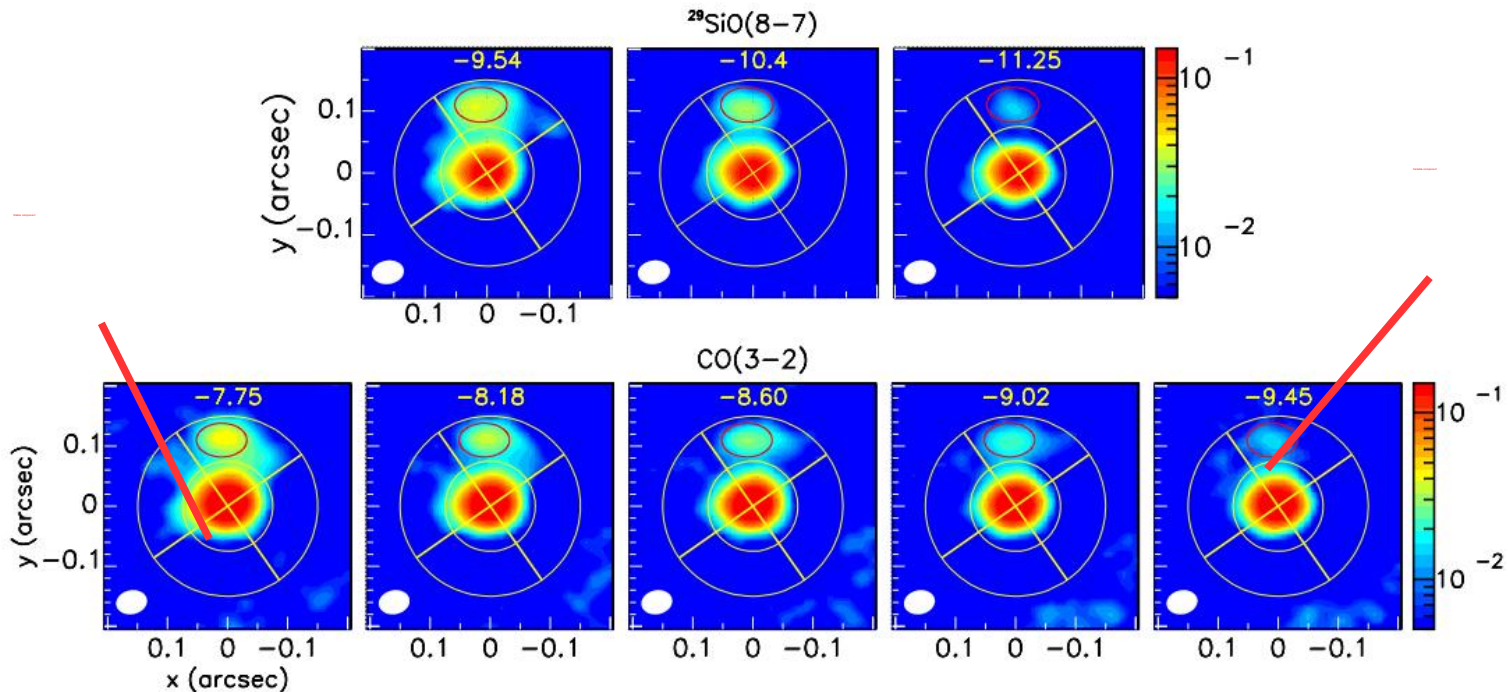
CO(2-1)



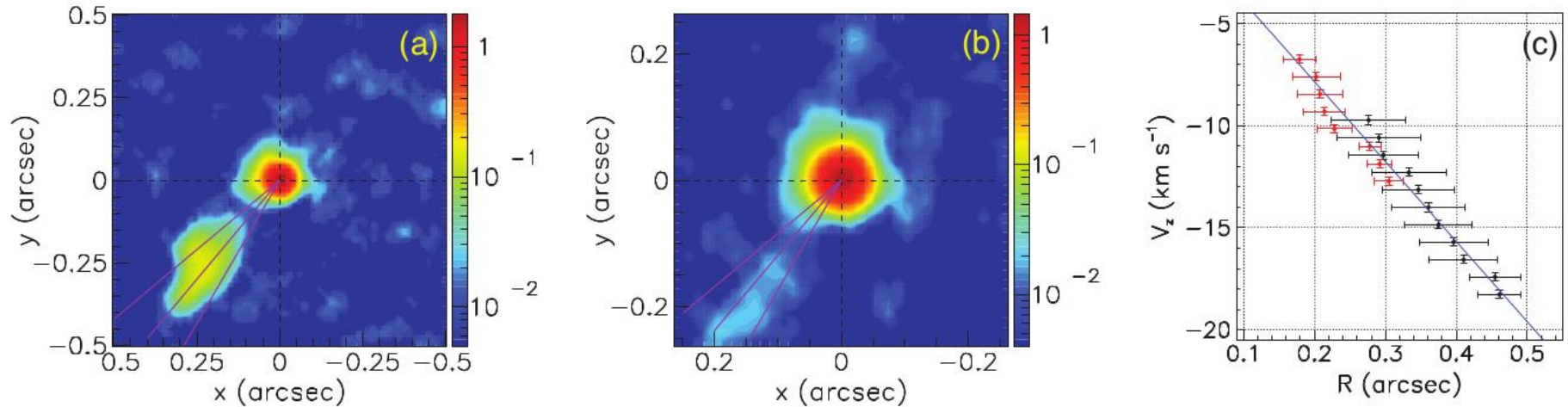
W Hya: a two-component picture

The stable component consists of an approximately spherical shell of gas and dust expanding radially to a terminal velocity of $\sim 5 \text{ km s}^{-1}$ at a distance of $\sim 30 \text{ au}$ from the star.

The variable component confined to the neighbourhood of the star toward north. Its very high density and sudden acceleration suggest an interpretation in terms of mass ejection initiated a few years ago.

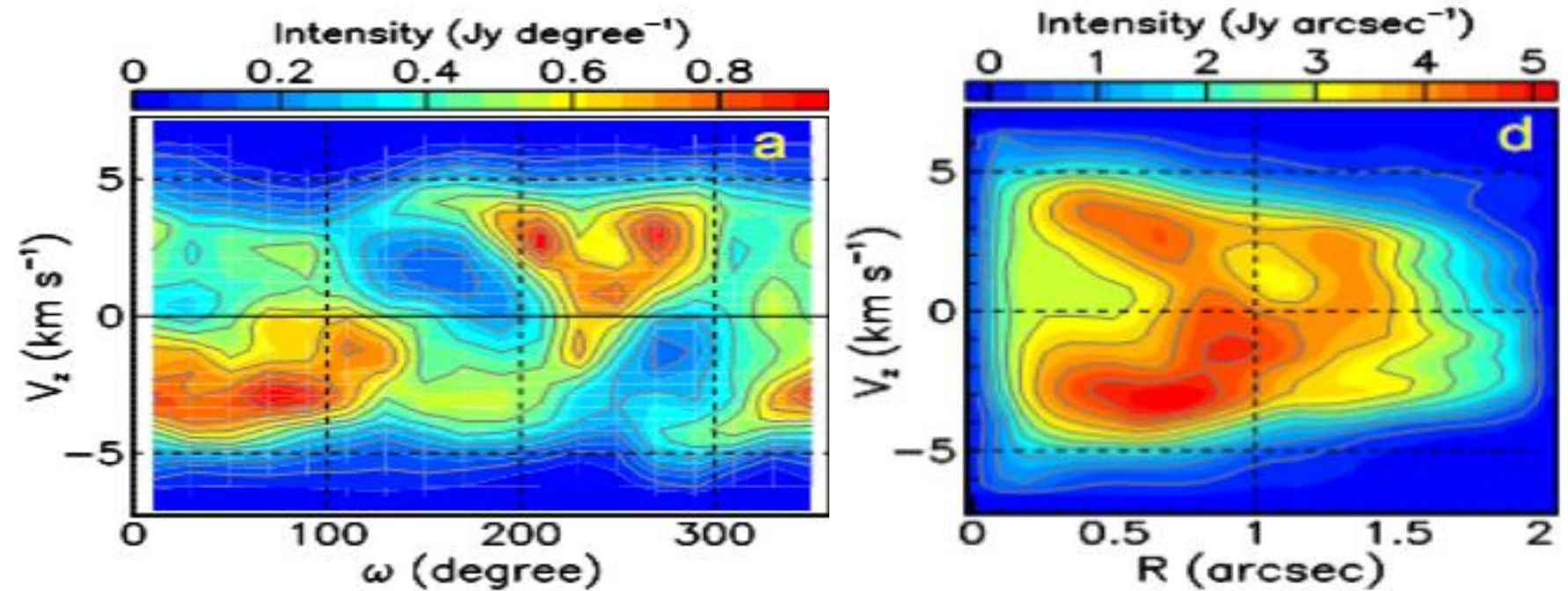


R Dor: a blue stream



A blue-stream is observed, emitted by the star and accelerating in the south-east blue-shifted direction. Close inspection of its properties contradicts an interpretation in terms of an evaporating planetary companion, suggested earlier by various authors but suggests instead a recent mass ejection.

R Dor



The radial structure of the wind suggests a recent episode of enhanced mass loss

In 2017, Vietnam joined the East Asia Observatory (EAO) as an observer. Vietnamese astronomers can use EAO's facilities. Currently, we are actively joining the activities of the Observatory: co-proposing large programmes and analyzing data from these programmes, taking shift, serving on TAC, participating EAO users meeting.



Vietnam Astrophysics Research NETwork (VARNET) was established in 2020 to train young researchers in Astrophysics and promote collaboration among Vietnamese researchers. Our main research focuses on understanding the roles of magnetic fields and dust in star formation and stellar feedback.

Simons Astrophysics Group at ICISE (SAGI) is founded in 2022 under the grant awarded by the Simons Foundation to IFIRSE. The mission is to foster collaborative research in astrophysics between international experts and the local researchers and to train young researchers in Astrophysics. They hold regular monthly seminar series.

Astrophysics conferences/workshops in 2022

- Star Formation in Different Environments (SFDE2022), 22 - 26, August, 2022, ICISE, Quy Nhon, Vietnam.

<https://www.icisequynhon.com/conferences/2022/SFDE/overview.html>

- International Training Workshop on Astronomy and Astrophysics, 23-25 September, 2022, Da Nang, Vietnam (VNSC+NARIT)

- The 16th International Symposium on Origin of Matter and Evolution of Galaxies (OMEG16), 25-28 October 2022, Hanoi, Vietnam <https://iop.vast.ac.vn/~omeg16/>

**NARIT-VNSC TRAINING
WORKSHOP ON ASTRONOMY FOR
STEM EDUCATION
DA NANG, VIETNAM, SEPTEMBER
2022**



The aim of the workshop is to equip university lecturers, high school teachers, graduate students and young researchers with updated knowledge and skills necessary for their STEM education activities, in particular the use of astronomy for STEM education.



OUTREACH AND TRAINING

Several amateur astronomer clubs

Planetariums and similar initiatives at various places,
Hoa Lac, Quy Nhon, Nha Trang, Vinh...

Good introduction to astronomy/astrophysics

given to space science students at University of Science and
Technology of Hanoi (USTH) and future high school teachers
in universities of education in TP HCM and Hanoi.

There are a couple of dozens of students (master, Ph.D, and
postdoc) studying abroad on astronomy/astrophysics. Some
are coming back to the country.

Vietnam team at IOAA



2016 India: 1 silver medals, 4 H.Ms.

2017 Thailand: 2 silver medals, 2 H.Ms.

2018 China: 1 gold medal, 1 silver medal, 2 bronze medals

2019 Hungary (two teams): 1 gold medal (absolute winner), 3 silver medals, 3 bronze medals, 1 H.M

2021: 2 gold, 1 silver, 2 bronze medals

2022: 1 silver, 5 bronze medals, 1 H.M

VNSC is heading the Vietnam Space Center project. The headquarter is being built in Hoa Lac High-Tech Park (30 km, west of Hanoi). It includes two observatories equipped with two planetariums (60 and 100 seats) and two 0.5 m optical telescopes, aimed at fostering interest on astronomy in the country and at helping with the training of students.



60-seat and 100-seat planetariums at Nha Trang and Hoa Lac Observatories



ICISE is completing the Science Exploration Center for public outreach and education where there are three exhibition rooms, a planetarium and an observatory.



International Center for Interdisciplinary Science and Education

The founder of the center is an overseas Vietnamese, Prof. Jean Tran Thanh Van. **ICISE organises each year about 15 conferences and schools, out of that about 1/3 on astronomy/astrophysics.**

A school, so-called Vietnam School of Astrophysics (VSOA) has been organized annually since 2013.



Summary

In over twenty years, we have been able to build up a team having sufficient expertise in radio astronomy to contribute research at international level in stellar physics and in the study of high redshift galaxies. We are doing our utmost to be able to pursue the three lines of research, evolved stars, star formation and galaxies of the early Universe.

Fundamental research is not a priority in Viet Nam and little support is given to team work in the academic and research environment. Recognition of our achievements by our foreign collaborators and colleagues is therefore most rewarding.

Summary

We are making extensive use of the open data policy of the ALMA collaboration who make their observations publicly available one year after collection. This generous policy is an invaluable asset to teams such as ours, working in developing countries having otherwise no direct access to frontier astrophysics. We are immensely indebted and grateful to the ALMA partnership.

We also thank EAO for a very generous offer to let us become an observer member.

We are working toward collaborating with Asian countries, in particular Japan, South Korea, Thailand, Taiwan and China. We do our utmost to promote fundamental research in the country by teaching in various universities and taking part in outreach events of various kinds, in particular having contacts with amateur astronomer clubs.

Thank you for you attention!