The Origin of Odd Radio Circles

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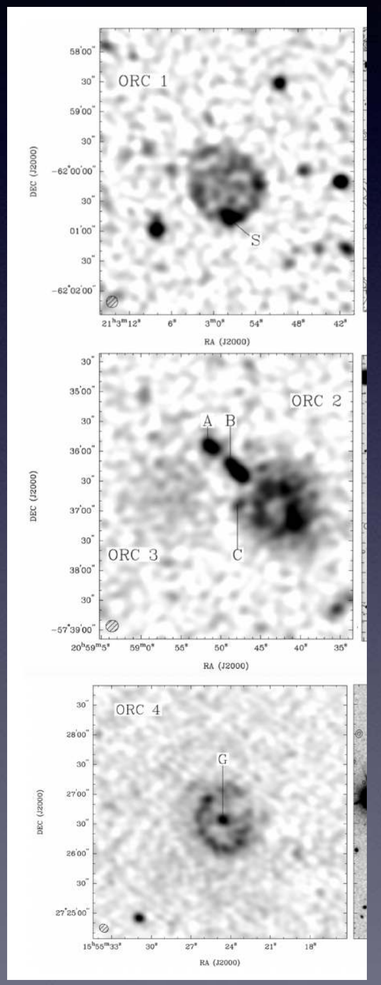
Odd Radio Circles

In 2021 a new class of extragalactic objects was discovered!

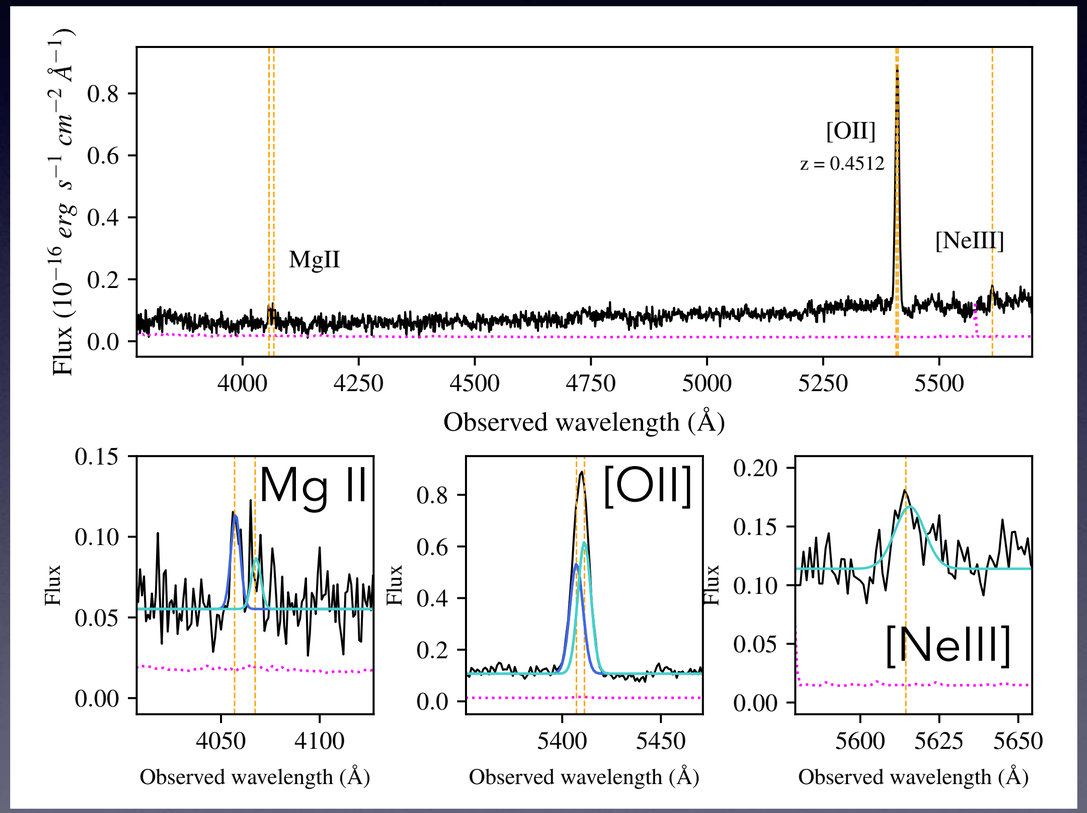
- ORCs: Odd Radio Circles
- Large rings of low surface brightness radio continuum emission
- ~1 arcmin across on sky (really big!!)
- Discovered by ASKAP, new radio array sensitive to faint emission
- Many have galaxies at the centers, photometric redshifts z~0.5
- Implies diameters of radio emission of 100s of kpc!
- Origin is unclear



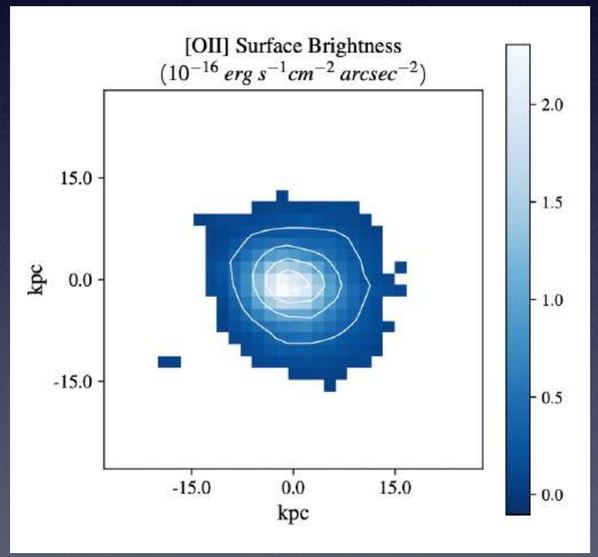
R. Norris et al., PASA, 2021

ORC4 Host Galaxy with Keck Cosmic Web Imager

host galaxy spectrum



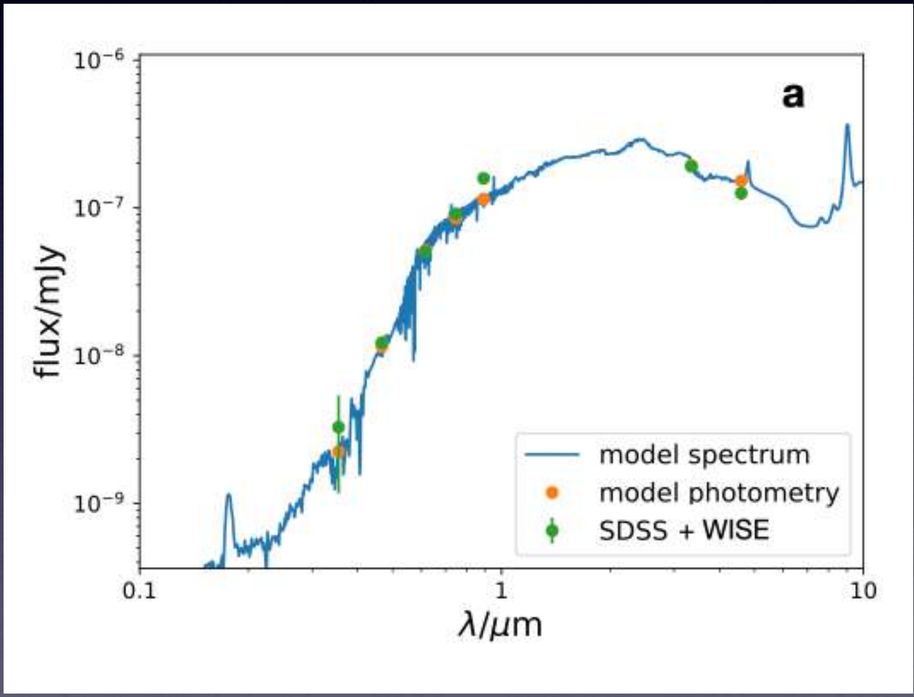
[OII] (singly ionized oxygen) map



Coil et al. *Nature*, 2024

- found that [OII] has high velocity dispersion: gas is churned

ORC4 Host Galaxy Photometry Fit



z = 0.4512; extragalactic, ORC radius is ~200 kpc

Host galaxy is massive and most stars are old (6 Gyr)

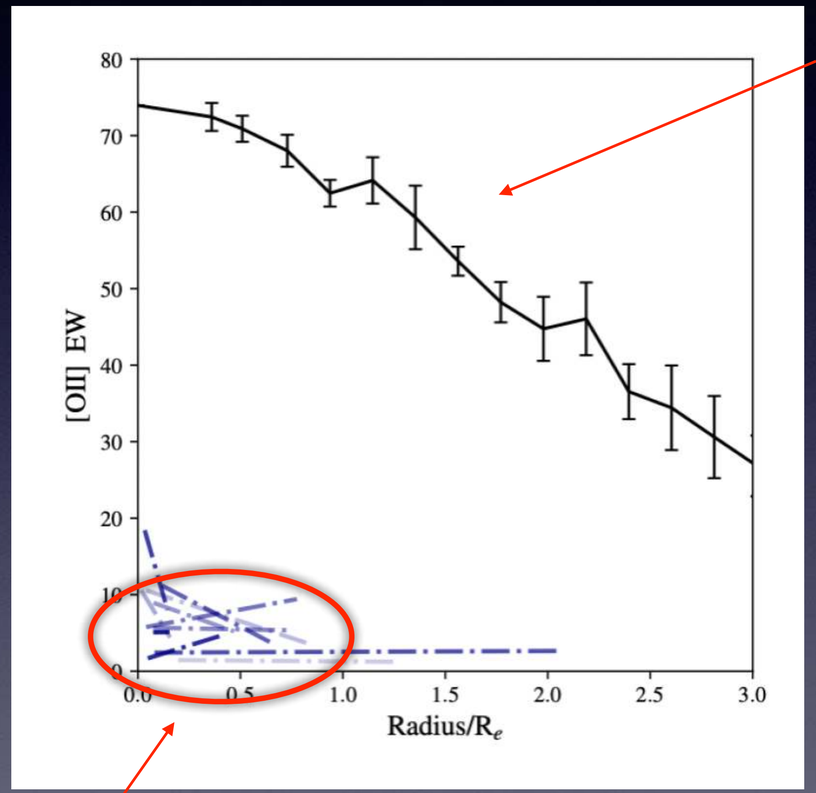
If we allow for a burst in the star formation history, the best fit has a strong burst of star formation ~1 Gyr ago

Coil et al. *Nature*, 2024

[OII] gas emission

[OII] gas emission relative to emission from stars

[OII] equivalent width



[OII] in ORC4

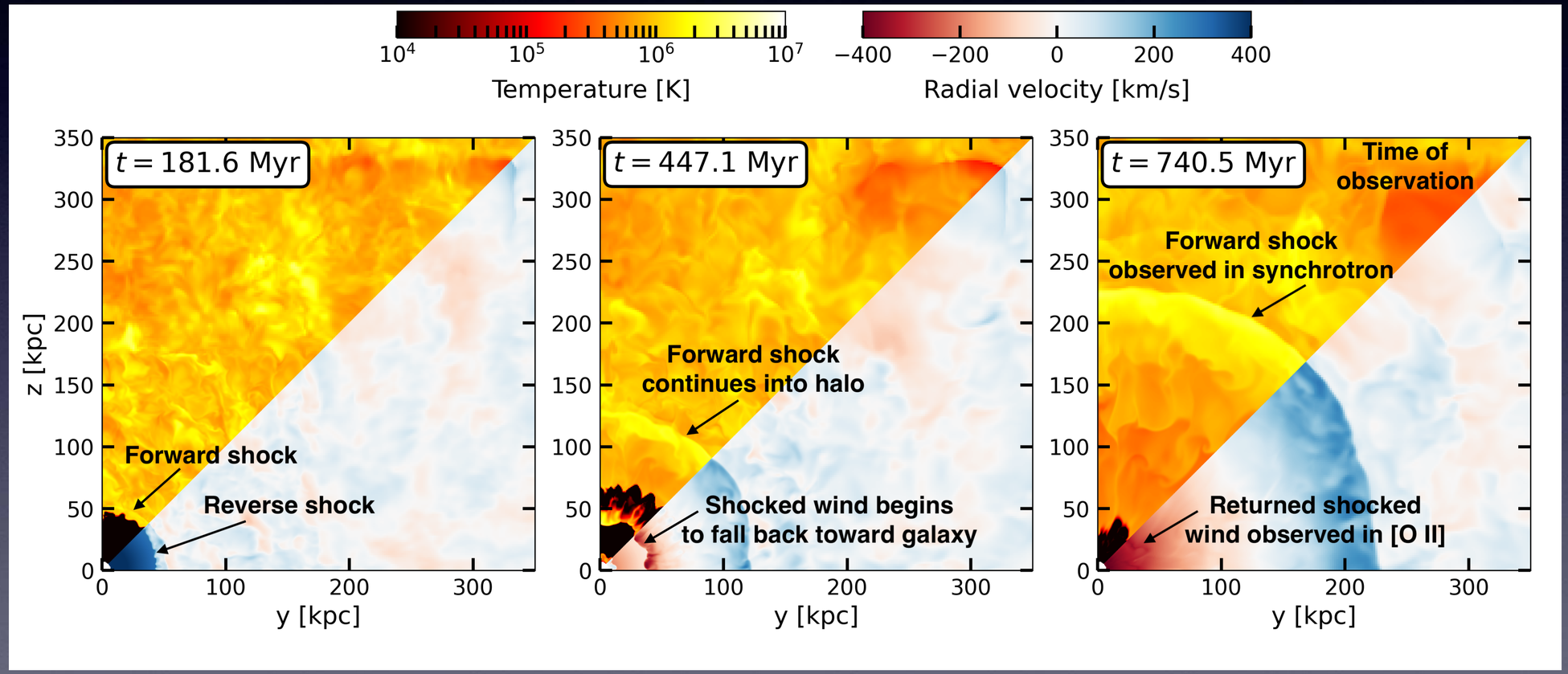
Tons of [OII] emitting gas, far out in the galaxy!

What is causing this [OII]??

radius / effective radius

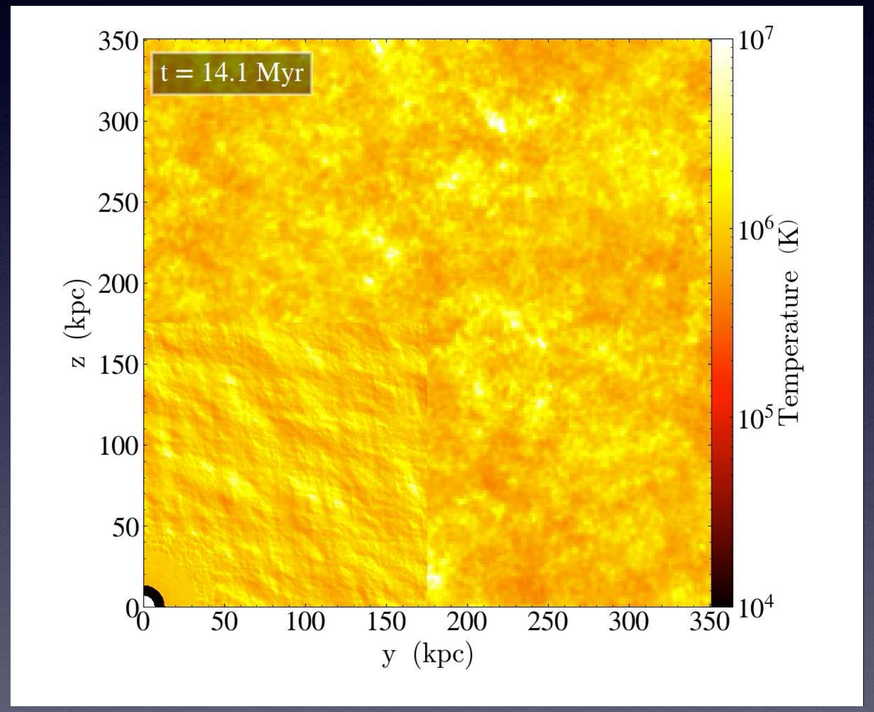
[OII] in other early-type galaxies

Outflowing Galactic Wind Model



Snapshots are time since wind started

[OII] related to ORC origin

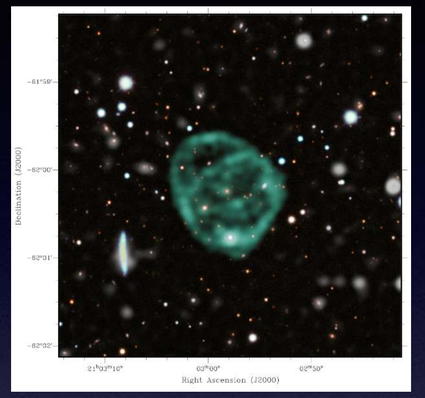


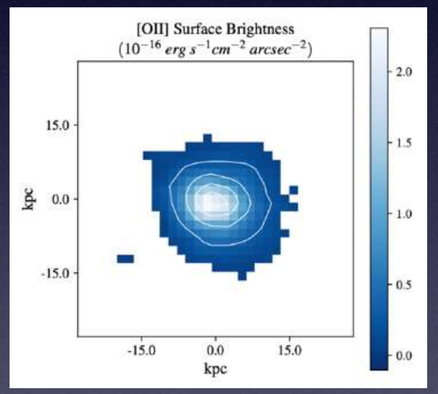
The *same* event caused both the large scale ORC radio ring and the smaller scale [OII] gas emission!

A starburst-driven wind drives a forward shock out of the galaxy. Once the wind shuts *off*, shocked wind gas from the reverse shock travels back towards the galaxy, as the forward shock continues to move outward to larger radii.

Outflowing wind origin for ORCs

One of the theories for the origin of ORCs is a shock from a starburst-driven wind.





We observed extended [OII] over 40 kpc in an ORC host galaxy that is consistent with shocked wind from the same energetic event that caused the ORC, as gas falls back onto the host galaxy.

Motivates the origin of ORCs (or at least this ORC) as an outflowing galactic wind. Helps solve the mystery of what causes ORCs and helps us "see" outflowing winds *after* they happen. Can also probe properties of gas around galaxies on very large scales!

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