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Northern Sky Narrowband Survey DR0.2: First [OIII] and [SII] results

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ABSTRACT

Data release (DR) 0.2 of the Northern Sky Narrowband Survey, with a complete set of H α , [OIII], [SII], and continuum data of the northern hemisphere down to a declination of -16° , is presented. To the best of my knowledge, this is the first time ever that [OIII] and [SII] data of such a large region have been published. The first part of this article briefly introduces the project and provides an overview of the available resources. In the second part, some remarkable observations are presented: a 17° -large OIII arc in Gemini that partially overlaps with the Monogem Ring; the possible closest planetary nebula around the hot subdwarf BD+28 4211 with an apparent diameter of $6''$; a faint 2.7° -large OIII ring, which also might be a planetary nebula; and a smaller but relatively bright object in Auriga, which can be seen at all observed wavelength.

Keywords: Sky surveys (1464) — ISM (847) — Emission nebulae (461) — Planetary nebulae (1249) — Supernova remnants (1667)

1. THE PROJECT

The survey was started by me at the end of 2018 with an array consisting of four H α (656.3 nm) cameras with a resolution of $9''$ (FWHM of a point source) and two continuum cameras with a resolution of $17''$. The first complete results from these early instruments were released in DR0.1 in 2024. Around 2023, a second array with three [OIII] (500.7 nm) and three [SII] (671.7 nm and 673.0 nm) cameras was installed. The resolution of these instruments is $10''$.

The passband width (FWHM) of the filters is 3.5 nm for H α and 4 nm for [OIII] and [SII]. The continuum cameras have sensors with a Bayer color filter array and were equipped with a light pollution filter. On these cameras, lenses with a focal length of 135 mm and front-mounted filters are used, so the aperture is determined by the filter size – 6 cm for the narrowband cameras and 7 cm for the continuum cameras. Since the transmission wavelength of the (interference) filter depends on the incident angle, the usable field of view of the narrowband cameras is limited by the passband width: $7.6^\circ \times 5.8^\circ$ for H α , and $10^\circ \times 6.8^\circ$ for [OIII] and [SII]. Because there is no limitation of the permissible incident angles, the continuum cameras can use the full lens-constrained field of view of $15.5^\circ \times 10.3^\circ$.

DR0.2 contains data collected between November 2018 and April 2025. Results are computed from about $7.4 \cdot 10^5$ single images (H α : $3.63 \cdot 10^5$, [OIII]: $1.00 \cdot 10^5$, [SII]: $1.09 \cdot 10^5$, Continuum: $1.68 \cdot 10^5$), with a total exposure time of about 11591 hours (H α : 6027 h, [OIII]: 1664 h, [SII]: 1816 h, Continuum: 2084 h).

The survey is operated from Pulsnitz, Germany, at a geographic latitude of $51^\circ 11'$. The location allows observations down to a declination of -16° .

1.1. Resources and data products

Numerous resources are available on the project's website and are presented in the overview below:

<http://www.simg.de/nebulae3>: Entry page of the Northern Sky Narrowband Survey.

<http://www.simg.de/nebulae3/instruments.html>: Instrument description.

http://www.simg.de/nebulae3/dr0_2: Documentation of the DR0.2.

http://www.simg.de/nebulae3/dr0_2/#overview: Overview and tile images with a maximum center resolution of $30''$ and $10''$, respectively. The images can be analyzed with a feature-rich JavaScript viewer (e.g., position and distance measurements; plotting catalog, SIMBAD or user-defined objects; SIMBAD queries; etc.).

http://www.simg.de/nebulae3/dr0_2/#hips: Numerous HiPS (Hierarchical Progressive Surveys) viewable with tools like Stellarium, Aladin, or Aladin Lite; and optimized for different purposes:

- Compressed 8-bit and color HiPS for visualization.
- FITS HiPS with linear intensity, approximately calibrated to Rayleigh or Rayleigh per nm, for scientific use
- Variance HiPS to assess data accuracy

The HiPS are also propagated by the HiPS aggregator ² and the IVOA registry. These are also the ways client applications find them. (To find them within the client, the search term ‘NSNS’ is helpful.)

<http://www.simg.de/query.html>: Image queries for given coordinates or objects (SIMBAD or user-defined)

2. OBSERVATIONS

It is no surprise that the first [OIII] and [SII] survey of such a large region reveals many previously unknown nebulae. Four remarkable objects are presented here.

2.1. OIII arc in Gemini

A $17^\circ \times 3^\circ$ -large OIII arc was detected in the constellation Gemini. Its center position is located at a right ascension of $\alpha_c = 7^{\text{h}}41^{\text{m}}48^{\text{s}}$ and a declination of $\delta_c = 19^\circ54'$. The nebula is depicted in Figure 1a (the red structure in the top right quarter). A central region, about 2.5° in size, is only visible in $\text{H}\alpha$ and [SII]. The northern region (right in the image) can be seen in all observed wavelengths, while the southern part was detected only in [OIII].

The arc partially overlaps with the Monogem Ring supernova remnant (SNR), which is marked by a dotted line in the image. Its position was estimated from visual filaments and is a good match with the latest measurements by J. R. Knies et al. (2024) et al., using X-ray data from the eROSITA instrument. (The authors consider two scenarios, a single SNR or two separate ones.) The faint filaments east of the arc (up in the image), which seem to cross the arc near its center, probably belong to the Monogem Ring. Since their structure differs from that of the arc, and the northern part of the arc clearly lies outside of the Monogem Ring, it is unlikely that the arc is part of the Monogem Ring SNR.

The nature of this object remains uncertain. A longer discussion of this topic and more data can be found at S. Ziegenbalg (2024).

2.2. Possible closest planetary nebula

An unstructured, approximately 5° -large OIII region was detected on the border between the constellations Pegasus and Cygnus, at $\alpha_c = 21^{\text{h}}51^{\text{m}}04^{\text{s}}$ and $\delta_c = 28^\circ59'$. Close to its center lies the nearby – about 112 ± 1 pc, Gaia Collaboration et al. (2023) – hot subdwarf BD+28 4211. Thus, this object might be a planetary nebula (PN) slightly closer than Sh2 216 (about 127 ± 1 pc, Gaia Collaboration et al. (2023)), which is usually considered the nearest PN.

Interestingly, SIMBAD ³ currently lists 825 papers that mention the subdwarf, but none appear to mention a PN surrounding this star (though not all papers were individually reviewed).

The nebula (mostly red) and the possible progenitor are shown in Figure 1b. The $\text{H}\alpha$ and [SII] filaments (cyan, the brightest are designated *Sh2 111*) appear to belong to supernova remnants originating in Cygnus. In the outer regions, there is a very faint [SII] glow (bluish) that does not appear to belong to the filaments. Including this emission, the apparent diameter of the nebula is about 6° . The morphology is typical for an ancient PN, and assuming a distance of 112 pc, its true diameter is about 12 pc (38 light-years).

2.3. OIII ring

A faint, approximately 2.6° -large OIII ring was detected on the border between the constellations Ursa Minor and Draco, at $\alpha_c = 15^{\text{h}}02^{\text{m}}51^{\text{s}}$ and $\delta_c = 66^\circ51'$. As shown in Figure 1c, only [OIII] emission could be detected from this object. Near the center, the white dwarf PG 1501+664 is located and lies at a distance of 464 ± 11 pc. Thus, this object is another candidate for an old and large PN (21 pc or 69 light-years assuming a distance of 464 pc).

² <https://aladin.cds.unistra.fr/hips/list>

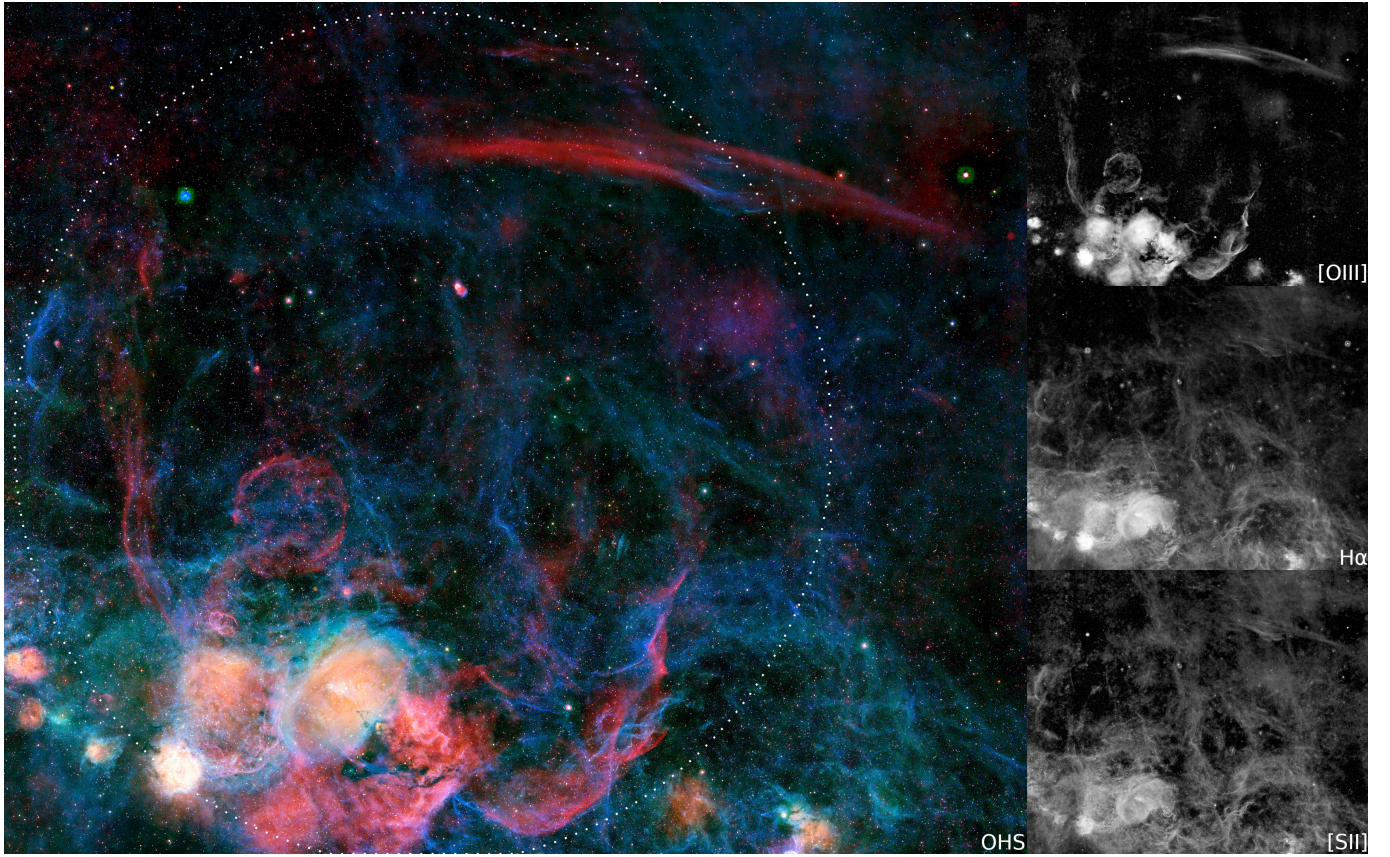
³ <https://simbad.cds.unistra.fr/simbad/sim-basic?Ident=BD%2B28+4211&submit=SIMBAD+search>

2.4. *Bright emission nebula*

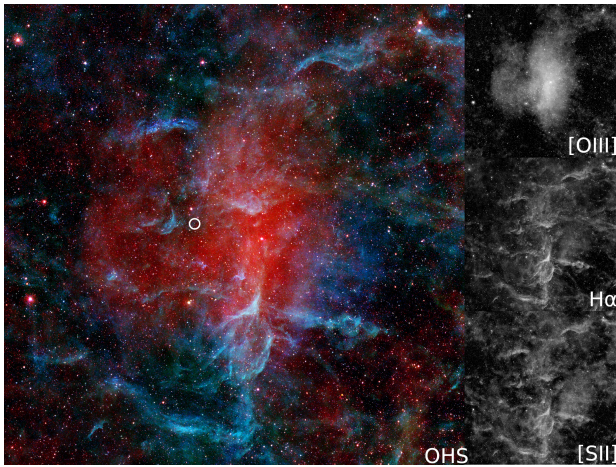
The object is located in the constellation Auriga at $\alpha_c = 6^{\text{h}}39^{\text{m}}13^{\text{s}}$ and $\delta_c = 40^{\circ}38'$. Compared to the nebulae above, it is relatively bright and small – about $0.85''$. As can be seen in Figure 1d, this object is also visible in the other observed wavelengths SIMBAD reports a few white dwarfs and white dwarf candidates in that region; however, none of them is close to the center. Thus, the nature of this object is uncertain.

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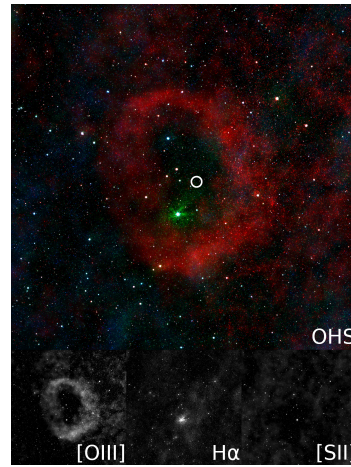
- Gaia Collaboration, Vallenari, A., Brown, A. G. A., et al. 2023, *A&A*, 674, A1, doi: [10.1051/0004-6361/202243940](https://doi.org/10.1051/0004-6361/202243940)
- Knies, J. R., Sasaki, M., Becker, W., et al. 2024, A new understanding of the Gemini-Monoceros X-ray enhancement from discoveries with eROSITA, <https://arxiv.org/abs/2401.17289>
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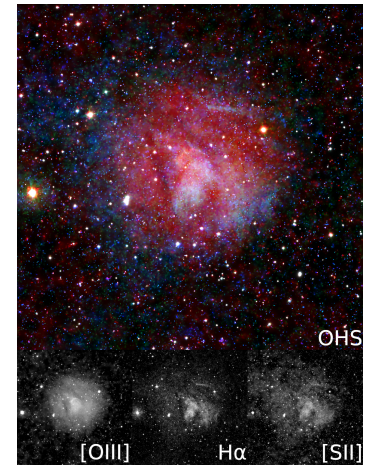
(a) OIII arc (top right, red) in Gemini. This object most likely does not belong to the Monogem Ring (dotted line), whose optical filaments can also be seen in this image. FOV: $30^\circ \times 25^\circ$.



(b) Unstructured [OIII] region (red) in the direction of the nearby (about 110 pc or 360 light-years) hot subdwarf BD+28 4211 (marked by a small circle). This might be the closest planetary nebula. The bright Hα and [SII] filaments (cyan) appear to belong to supernova remnants that originate in Cygnus. FOV: $9^\circ \times 9^\circ$.



(c) Faint OIII ring, which might be a planetary nebula. The possible progenitor, the white dwarf PG 1501+664, is marked by a small circle. FOV: $5^\circ \times 5^\circ$.



(d) Relatively small and bright nebula that can be seen in all observed wavelengths. Its nature is uncertain. FOV: $1.6^\circ \times 1.6^\circ$.

Figure 1. Four objects with dominant [OIII] emission. In the color images, [OIII] is mapped to red, Hα to green, and [SII] to blue. The smaller grayscale images show the same color channels separately, as denoted. The Brightest stars are added to visualize regions contaminated by intense continuum light and for orientation. Aside from that, the image does not contain continuum light. North is right, and east is up. A short description and the field of view (FOV) are given below the panels.