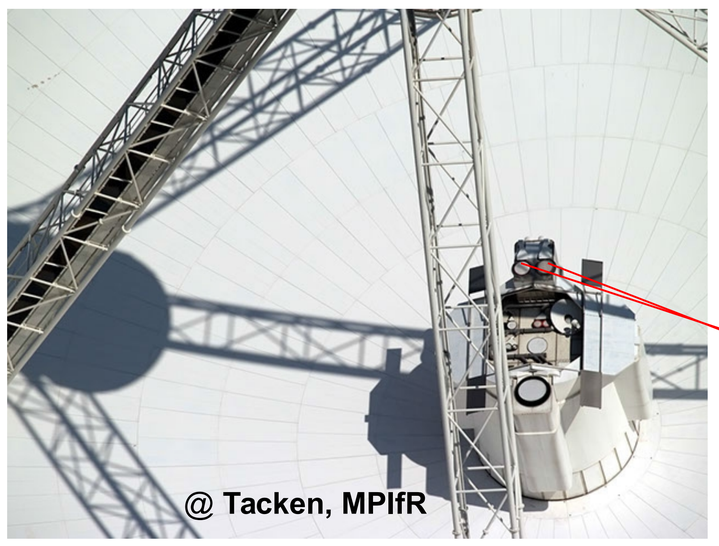
The new high-latitude low-surface brightness SNR G181.2+9.5

P. Reich[1], R. Kothes[2], T. J. Foster[2,3], W. Reich[1]

[1] Max-Planck-Institut für Radioastonomie, Bonn, Germany, [2] NRC, Dominion Radio Astrophysical Observatory, Penticton, Canada, [3] Brandon University, Canada

We have discovered a new faint SNR in the Galactic Anti-centre with the DRAO synthesis telescope at 21 cm (Kothes et al., in prep.). G181.2+9.5 is an almost circular very faint shell-type SNR with a diameter of about 80′.
Here we report on follow-up observations with the Effelsberg 100-m telescope at 6 cm. G181.2+9.5 is highly polarized with a tangential magnetic field and fainter filamentary structures inside. Its faintness makes it difficult to measure its integrated total emission, because of confusing extragalactic sources. The total-intensity spectral index α of the clearly visible eastern filament was found from TT-plots (21 cm/6 cm) to be α = -0.35 ± 0.2 ($S \sim \nu^{\alpha}$) and we obtain a percentage polarization of 68 ± 15 %. At 6 cm, we measure about 0.2 Jy for the integrated polarized intensity. In case the eastern shell properties represent the entire SNR, its radio surface brightness is about 1.4 10^{-23} W m^{-2} Hz^{-1} sr^{-1} , or about three times below the lowest SNR surface brightness reported so far by Foster et al. (2013) for G190.9-2.2. High-velocity HI-gas from the 'Anti-Center Shell' seems to be associated with G181.2+9.5. Its distance is not well constrained, but larger than 0.5 up to 2.5 kpc. This translates into a SNR diameter between 12 pc and 60 pc.

6-cm observations

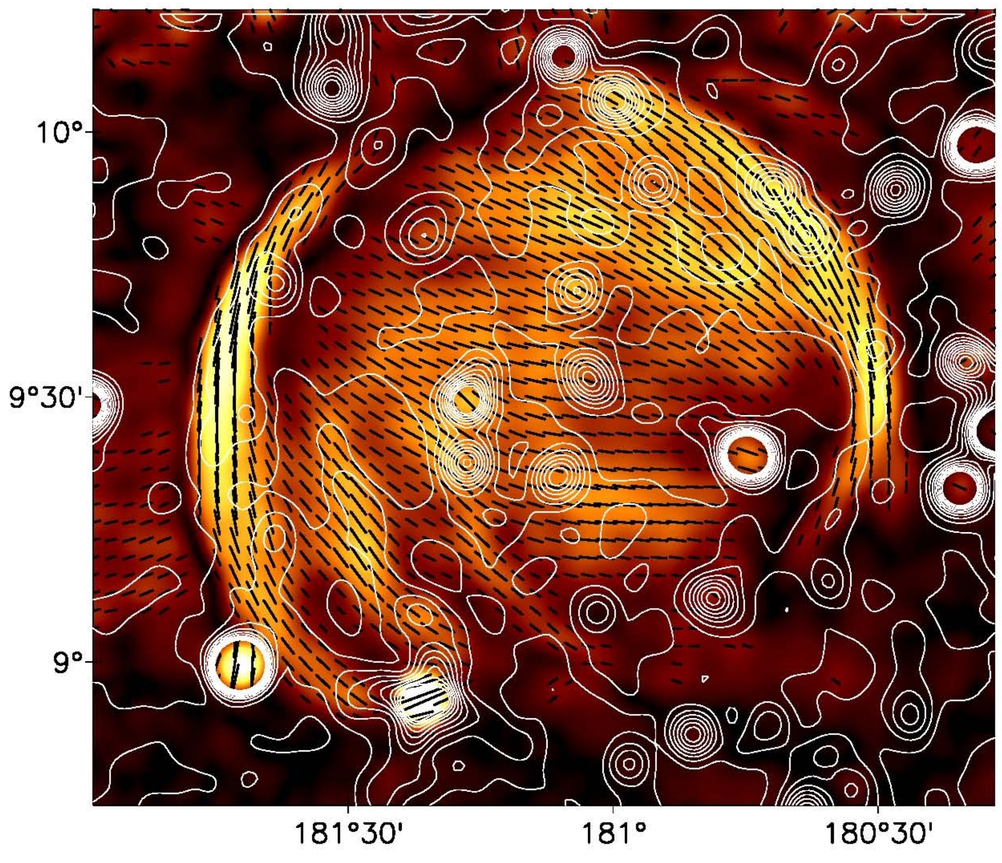


The 6-cm total-intensity and polarization observations have been made with a dual beam receiver from the secondary focus of the Effelsberg 100-m telescope. The two 6-cm beams with 2.43′ HPBW have an offset of 8.3′ along the azimuth direction.

Between December 2013 and May 2015, a large number of maps was observed at night time and only at clear skies. Due to strong unpolarized RFI of unknown origin, about half of the collected total-intensity data could not be used and the other half needed intensive editing. To cover G181.2+9.5, we had to map a very large area, where the standard mapping procedure for 6-cm dual beam observations along azimuth direction and subsequent restoration will loose large-scale emission. Thus we conducted the observations in single beam mode by moving the telescope either along Galactic longitude or latitude.

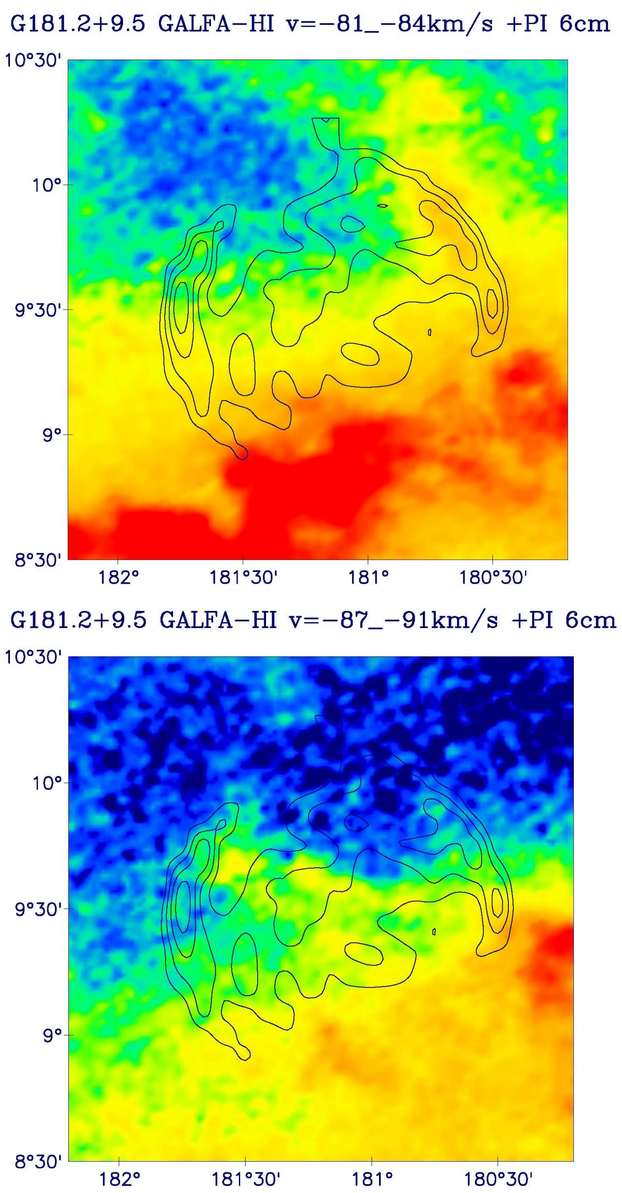
The data for both feeds were processed independently following the standard procedures for Effelsberg continuum observations based on the NOD2 format (Haslam, 1974). After flagging distorted areas and spiky interference, baseline improvement of each observed map was done by using the method of unsharp masking (Sofue & Reich, 1979). The final map was obtained by adding the edited and calibrated maps in the Fourier domain using the PLAIT-algorithm described by Emerson & Gräve (1988).

6-cm results



The map shows linearly polarized 6-cm emission with white total-intensity contours overlaid. The polarization bars are in B-field direction. The foreground RM is negligible for this area. The sensitivity of the total intensity map is limited by confusion noise, which, fortunately, has no effect on the sensitivity of the polarization data. The percentage polarization of the shell of 68 ±15 % is close to the intrinsic value for a regular magnetic field with no turbulence.

Interaction of G181.2+9.5 with high-velocity HI gas



Slightly smoothed polarized 6-cm intensity contours of G181.2+9.5 overlaid on high-velocity HI (HVC) - emission from the GALFA survey carried out with the Arecibo telescope (Peek et al., 2011). We show two velocity intervals. The south-western area of the SNR shell gets depolarized where the HI-intensity in the velocity range from -81 to -84 km/s significantly increases and the western shell has a faint HI-counterpart. A patchy filamentary structure is seen towards the central part of the SNR.

The HVC gas is part of the huge Anti - Center Shell identified by Heiles (1984), which extends for about 30° in the sky. Kulkarni & Mathieu (1986) used Ca K absorption features of stars with known distances and found that the Anti-Center Shell is more distant than 0.5 kpc. The maximum distance is 2.5 kpc, or may be even larger depending on the abundance of Ca .

Preliminary results and perspectives

Despite some parameters of the faint SNR G181.2+9.5 could not be measured with high precision so far, its clear detection at 21 cm and 6 cm demonstrates the existence of faint high-latitude SNRs with almost no influence by magnetic turbulence as indicated by its almost intrinsic degree of polarization at 6 cm. There are a number of similarities with the SNR G156.2+5.7 (Reich et al., 1992, Xu et al., 2007) located outside of the Galactic plane. This SNR has a very low surface brightness as well and also a high percentage polarization exceeding 50% up to 75%.

We note that SNRs similar to G181.2+9.5 will show up more clearly in high-frequency polarization maps rather than in the corresponding confusion limited total-intensity maps. Although G181.2+9.5 has the lowest surface-brightness measured for Galactic SNRs so far, its detection seems to depend on its association with HVC gas providing a higher density compared to the high-latitude hot gas in the anti-centre for z-values between 80 pc and 400 pc. Clearly, modelling is required to understand this so far unique scenario of SNR interaction with HVC gas.
We will soon present more data of G181.2+9.5 and will discuss its properties in some detail (Kothes et al., in prep.).

References

Emerson & Gräve, 1988, A&A, 190, 353
Foster et al., 2013, A&A, 549, A107
Haslam, 1974, A&AS,15, 333
Heiles, 1984, ApJS,55, 585
Kulkarni & Mathieu, 1986, Ap&SS, 118, 53
Peek et al., 2011, ApJS, 194, 20
Reich et al., 1992, A&A, 256, 214
Sofue & Reich, 1979, A&AS, 38, 251
Xu et al., 2007, A&A, 470, 969