Star formation in hosts of young radio galaxies
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Abstract
We present near ultraviolet imaging with the Hubble Space Telescope Advanced Camera for Surveys, targeting young radio galaxies (Gigahertz Peaked Spectrum and Compact Steep Spectrum sources), in search of star formation regions in their hosts. We find near UV light which could be the product of recent star formation in eight of the nine observed sources. However, observations at other wavelengths and colors are needed to definitively establish the nature of the observed UV light. In the CSS sources 1443+77 and 1814–637 the near UV light is aligned with and is co-spatial with the radio source, and we suggest that in these sources the UV light is produced by star formation triggered and/or enhanced by the radio source.

Key words: Galaxies: stellar content, Galaxies: photometry, Ultraviolet: galaxies

1. Introduction

The relationship between black hole mass and galaxy mass implies that the growth and evolution of black holes (therefore AGN) and their host galaxies must somehow be related (e.g., Gebhardt et al., 2000). Mergers and strong interactions can trigger AGN activity in a galaxy (e.g., Heckman et al., 1986; Baum et al., 1992; Israel, 1998). These events can also produce instabilities in the ISM and trigger star formation (e.g., Ho, 2005). Numerical simulations (e.g., Mellema et al., 2002; Rees, 1989) suggest that the advancement of the jets through the host galaxy environment can also trigger star formation. UV studies of large 3CR sources find traces of episodes of star formation around the time when the radio source was triggered (i.e., \( \lesssim 10^7 \sim 10^8 \text{ yr} \), Koekemoer et al., 1999; Allen et al., 2002; O'Dea et al., 2001, 2003; Martel et al., 2002), suggesting a possible link between both.

Gigahertz Peaked Spectrum (GPS) sources and Compact Steep Spectrum (CSS) are young, smaller (GPS \( \lesssim 1 \text{kpc} \), CSS \( \lesssim 15 \text{kpc} \), for a review see O'Dea, 1998) versions of the large powerful radio sources, so they are expected to exhibit signs of more recent star formation. Their size makes them excellent probes of the interactions between the expanding lobes and the host. They have not yet completely broken through the host ISM, so these interactions are expected to be even more important than in the larger sources.

The near UV observations are very sensitive to the presence of hot young stars and therefore will
trace recent star formation events. We have obtained high resolution HST/ACS UV images of these young compact sources to study their morphology and the extent of recent star formation.

Our sample is chosen to be representative of GPS and CSS sources with $z \lesssim 0.5$, nearby enough to eliminate strong effects due to evolution with cosmic time. The objects are drawn primarily from the well-defined samples of Fanti et al. (1990, 2001) and Stanghellini et al. (1997).

2. Observations and data reduction

We obtained high resolution near-UV snapshot images with the High Resolution Channel (HRC) of the Advanced Camera for surveys (ACS) on board the Hubble Space Telescope, using the F330W filter. The objects observed are GPS and CSS galaxies 1117+146, 1233+418, 1345+125, 1443+77, 1607+268, 1814–637, 1934–638, 1946+708, 2352+495. Here we present preliminary results on the UV properties of these sources.

The two 2-D fitting code GALFIT (Peng et al., 2002) was used to parameterize the UV emission. For each image we tested different combinations of point source and Sersic profiles, allowing the sky level, position and magnitudes of all components, as well the index and effective radii of the Sersic components, to vary. The final model was chosen according to the lowest $\chi^2$ and best residuals (with the lowest number of components). There are no good models of the Point Spread Function (PSF) for the ACS/HRC. To model the PSF we used the calibration plan observations of Cycles 12 and 13.

The observed objects are Narrow Line Radio Galaxies (NLRG) so we expect no contamination from the AGN nucleus. The main contribution from emission line gas to our observations would come from MgII. It is usually only found in the nuclear Broad Line Region (BLR) of AGN hosts so we do not expect contamination from emission line gas either.

| Source       | Component | STMAG  | $R_e$ | Sersic index |
|--------------|-----------|--------|-------|--------------|
| 1117+146     | Point source | 24.06±0.06 |     |              |
| 1233+418     | Point source | 25.43±0.16 |     |              |
|              | Sersic profile | 24.21±0.36 | 100±800 | 0.04±0.6 |
| 1345+125     | Point source | 23.77±0.05 |     |              |
|              | Sersic profile | 21.14±0.02 | 35±0.5 | 0.33±0.03 |
|              | Sersic profile | 21.20±0.04 | 108±7 | 1.62±0.13 |
| 1443+77      | Point source | 25.21±0.10 |     |              |
|              | Point source | 24.06±0.06 |     |              |
|              | Sersic profile | 20.36±0.16 | 1.1"±0.2" | 2.66±0.33 |
| 1607+268     | Point source | 24.64±0.18 |     |              |
|              | Sersic profile | 23.13±0.14 | 47±11 | 3.92±2.35 |
| 1814–637     | Point source | 16.95±0.10 |     |              |
|              | Sersic profile | 17.11±0.12 | 25±4 | 2.08±0.31 |
| 1934–638     | Point source | 23.81±0.73 |     |              |
|              | Sersic profile | 21.75±0.12 | 39±5 | 1.02±0.33 |
|              | Sersic profile | 21.08±0.07 | 354±45 | 2.51±0.26 |
| 1946+708     | Point source | 25.81±0.25 |     |              |
|              | Point source | 24.59±0.09 |     |              |
| 2352+495     | Point source | 25.13±0.16 |     |              |
|              | Point source | 25.53±0.19 |     |              |
|              | Point source | 24.79±0.10 |     |              |

3. Results

The summary of the GALFIT models is shown in Table 1. The UV images together with GALFIT models are shown in Figure 1.

All sources consist of at least two components except 1117+146 (a point source). The hosts of 1233+418, 1345+125, 1443+77, 1607+268, 1814–637 and 1934–638 show a combination of at least one Sersic component (with different indices) and one or several point sources. 1946+708 and 2352+495 show a combination of two and three
point sources respectively\(^1\).

The two brightest sources in the UV, 1443+77 and 1814–637, show alignment of the UV emission with the radio source (see VLBI maps in [Tzioumis et al., 2002, Sanghera et al., 1995]). Both sources are CSS with radio sizes comparable to the separation between the UV components (\(\sim 7\) and \(\sim 0.5\) kpc respectively). The similarity in radio and UV sizes, alignment and higher UV emission suggest that the expansion of the radio source is enhancing star formation in the hosts of 1443+77 and 1814–637. [Labiano et al., 2005] found the presence of gas ionized by the shocks from the radio source in CSS sources. Furthermore, they find that 1443+77 shows the strongest contribution from shocks. We could expect these shocks to be affecting the star formation in the host too.

4. Summary

We have obtained HST/ACS near-UV high resolution images of young radio sources: GPS and CSS galaxies. We detect near UV emission (point sources and/or clumps) in eight of the sources, consistent with the presence of recent star formation. In two CSS sources, 1443+77 and 1814–637 the near UV emission is aligned with and co-spatial with the the radio emission and we suggest that star formation has been triggered/enhanced by expansion of the radio source through the host. Observations at other wavelengths and measurement of the colors are needed to further assess the nature of the observed UV properties.

References
Allen, M. G., Sparks, W. B., Koekemoer, A., Martel, A. R., O’Dea, C. P., Baum, S. A., Chibber, M., Macchetto, F. D., Miley, G. K., 2002. ApJS139, 411.
Baum, S. A., Heckman, T. M., van Breugel, W., 1992. ApJ389, 208.
Fanti, C., Pozzi, F., Dallacasa, D., Fanti, R., Gregorini, L., Stanghellini, C., Vigotti, M., 2001. A&A369, 380.
Fanti, R., Fanti, C., Schilizzi, R. T., Spencer, R. E., Nan Rendong, Parma, P., van Breugel, W. J. M., Venturi, T., 1990. A&A231, 333.
Gebhardt, K., Bender, R., Bower, G., Dressler, A., Faber, S. M., Filippenko, A. V., Green, R., Grillmair, C., Ho, L. C., Kormendy, J., Lauer, T. R., Magorrian, J., Pinkney, J., Richstone, D., Tremaine, S., 2000. ApJ539, L13.
Heckman, T. M., Smith, E. P., Baum, S. A., van Breugel, W. J. M., Miley, G. K., Illingworth, G. D., Bothun, G. D., Balick, B., 1986. ApJ311, 526.
Israel, F. P., 1998. A&A Rev.8, 237.
Koekemoer, A. M., O’Dea, C. P., Sarazin, C. L., McNamara, B. R., Donahue, M., Voit, G. M., Baum, S. A., Gallimore, J. F., 1999. ApJ525, 621.
Labiano, A., O’Dea, C. P., Gelderman, R., de Vries, W. H., Axon, D. J., Barthel, P. D., Baum, S. A., Capetti, A., Fanti, R., Koekemoer, A. M., Morganti, R., Tadhunter, C. N., 2005. A&A436, 493.
Martel, A. R., Sparks, W. B., Allen, M. G., Koekemoer, A. M., Baum, S. A., 2002. AJ123, 1357.
Mellema, G., Kurk, J. D., Röttgering, H. J. A., 2002. A&A395, L13.
O’Dea, C. P., 1998. PASP110, 493.
O’Dea, C. P., de Vries, W. H., Koekemoer, A. M., Baum, S. A., Axon, D. J., Barthel, P. D., Capetti, A., Fanti, R., Gelderman, R., Morganti, R., Tadhunter, C. N., 2003. Publications of the Astronomical Society of Australia 20, 88.
O’Dea, C. P., Koekemoer, A. M., Baum, S. A., Sparks, W. B., Martel, A. R., Allen, M. G., Macchetto, F. D., Miley, G. K., 2001. AJ121, 1915.
Peng, C. Y., Ho, L. C., Impey, C. D., Rix, H.-W., 2002. AJ124, 266.
Rees, M. J., 1989. MNRAS239, 1P.
Sanghera, H. S., Saikia, D. J., Ludke, E., Spencer, R. E., Foulsham, P. A., Akujor, C. E., Tzioumis, A. K., 1995. A&A295, 629.
Stanghellini, C., O’Dea, C. P., Baum, S. A., Dallacasa, D., Fanti, R., Fanti, C., 1997. A&A325, 943.

\(^1\) The Sersic profiles are used to parameterize the data. It does not necessarily imply that these UV components are galaxies.
Fig. 1. UV images (left panels) and GALFIT models (right panels). Only sources with complex morphologies in the UV image are shown.

Tzioumis, A., King, E., Morganti, R., Dallacasa, D., Tadhunter, C., Fanti, C., Reynolds, J., Jauncey, D., Preston, R., McCulloch, P., Tingay, S., Edwards, P., Costa, M., Jones, D., Lovell, J., Clay, R., Meier, D., Murphy, D., Gough, R., Ferris, R., White, G., Jones, P., 2002. A&A392, 841.