Colliding worlds science with Effelsberg

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Outline of the presentation

Today, I would like to say a few words about:

• Why do we love galaxy groups (and pairs)?
• Why do we hate galaxy groups (and pairs)?
• Colliding worlds science already done:
  • Discordant tails of Arp 269;
  • Cluster dead, group rebirth: HCG 15;
  • Space matryoshka: HCG 60;
  • The one and only Stephan's Quintet
• Prospects for future observations.
Why do we love galaxy groups?

Because they are fine targets for a study!

As noticed by Paul Hickson (1982), groups (and tight, compact pairs) are subjects to many interesting phenomena. Vicinity triggers activity, so one can expect to find:

1) Morphology distortions;
2) Gaseous outflows – tails, rings, etc;
3) Starburst activity;
4) Merging events;
5) Formation of tidal dwarf galaxies;
6) Many, many others...

Moreover, specific conditions inside some groups make them either resemble central regions of rich clusters, or field galaxies at \( z=1 \sim 2 \), making a piggyback science also possible.
Why do we hate galaxy groups?

Because they are among the worst targets for a radio astronomer.

A galaxy group manifest at radio wavelengths in a way that makes it difficult to be observed in most of the cases. Here are the basic reasons:

1) Weak radio emission;
2) Large angular extent;
3) Considerable distance – need for high resolution;
4) Steep radio spectrum;
5) Complicated history of interactions – harmful for regular magnetic fields;
6) Many, many others...

Despite that fact, a number of galaxy groups has been observed, starting from the Stephan's Quintet (Allen&Hartsuiker 1972).

Let's see if there is a point in overcoming these problems.
A dwarfish system with a heart tail of a giant

A relatively nearby galaxy system, known for a large neutral gas tail (Clemens et al. 1998)

- A radio study by Clemens et al. 1998 shows also a bowl of radio emission;
- Due to the presence of a storm of star formation, there are many compact sources of radio emission...
- ... as well as an intergalactic bridge, and disk radiation.

So why do we need the Effelsberg here?
Discordant tails of Arp 269

Because some information might be lost due to zero spacing!

Below are the effects of image plane merging (AIPS task IMERG) of the VLA CD and Effelsberg data at 4.86 GHz

The magnetised outflow does not correlate with the neutral gas one: it is a separate tail.
All Some dogs clusters go to heaven!

6 galaxies near the equator, so boring that no one even cared to name them

- At lower frequencies – 612 MHz (Giacintucci et al. 2011), and 1420 MHz (Nikiel-Wroczyński et al. 2017), there is a large radio halo;
- We don't see much at 4860 MHz with the VLA;
- Zero spacing might be an issue once again?

Let's compare this to an Effelberg map.
There is just that one source, smeared..

The Effelsberg map does not show any more emission. What does it mean? It confirms a very steep ($\sim -2.5$) spectrum of HCG 15. The extent, internal magnetic field, and steepness of the halo of this group bears some similarities with clusters.

There is a possibility, that HCG 15 is a very aged cluster, in which member galaxies have been colliding an ultimately left only a few of them surviving, plus a large radio envelope.
Radio galaxy inside a group, all inside a cluster

Technically, HCG 60 is not a “real” HCG, as it does not fulfill the isolation criterion.

- It is the very centre of Abell 1452 cluster;
- A head-tail radio galaxy dwells there (Miley 1976, Rudnick & Owen 1977);
- VLA high and low resolution images at 1420 MHz suggest that there might be a bit of extended emission there – possibly not connected with the RG, but the groups;
- To confirm/further study it, we need to have spectral index.

Let’s compare low- and hi-res images at 4.86GHz – using the Effelsberg for the former.
The space matryoshka: HCG 60
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Two faces of the space matryoshka

The Effelsberg map does show much more emission than the VLA one. Spectral index analysis, and comparison of hi- and lo-res fluxes at both frequencies suggests, that at 1420 MHz the extended emission dominates over the compact one. This is not the case at higher frequency.

We clearly see, how much of the emission is due to the extended structure, and that it is much steeper than the compact one.
The best known galaxy group!

Discovered in 1877, the Quintet is a well-studied system.

- Known to emit at frequencies below 5 GHz;
- Giant shock front caused by a galactic infall;
- How “high” can we trace the radio emission?

Effelsberg telescope allowed to detect polarisation at as high frequency as 8.35 GHz - this is, so far, the highest frequency at which polarised radio emission from a galaxy groups was detected.
What should you remember?

There are certain points that would be nice to remember:

• That we can study galaxy groups;
• That this makes sense, and yields results;
• That the Effelsberg telescope is a great tool to do so!
• That in many of the cases, it would not be possible to achieve the science goals without this instrument.

The future of observing? Polarisation at higher frequencies! Preferably, a receiver that could perform Rotation Measure Synthesis at frequencies over 10 GHz. Arp 269, HCG 60, SQ – all these systems could be perfect targets for such a backend.
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