From: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>
Subject: Re: Hercules A - Accepted for publication!
Date: Fri, July 2, 2021 8:24 am
To: abridle@nrao.edu

Thank you very much for the kind words! It was great to work on this paper with you, and I am very grateful for all your comments and suggestions.

Cheers,
Roland

On 2021-07-01 19:15, Alan Bridle wrote:
> On Thu, July 1, 2021 8:22 am, Roland Timmerman wrote:
>
> Great news, and once again thank you for all of your work (and
> diplomacy!) on
> getting it to this point. Best wishes for the rest of your research!
> I look
> forward to reading many more of your papers which I am sure will be
> forthcoming!
>
> Best regards,
>
> Alan Bridle
>
>> Hi all,
>>
>> I'm happy to announce that our paper on Hercules A was accepted for
>> publication!
>>
>> Once again, thank you all very much for your feedback and support! It
>> was an absolute pleasure to work with all of you, and I hope I will
>> have
>> the opportunity to do so again in the future.
>>
>> I'll upload the paper to arXiv soon, and will keep you updated.
>>
>> Cheers,
>> Roland
>>

From: "Alan Bridle" <abridle@nrao.edu>
Subject: Re: Hercules A - Second referee report
Date: Fri, June 25, 2021 8:16 pm
To: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>

Dear Roland

Thank you for sending me all of this. I agree with the conclusion that new simulation work is needed to make more definitive progress ... the longer term value of comprehensive new data like this is to raise the bar for what the numerical simulations will eventually try to match! So I am happy with the update! The ultimate role of these observations will be to preview what areas may be addressed with future instruments rather than to tie everything up in a totally neat bow now.

One tiny detail I noticed this time around: in the reference to Roger at al. 1973 the second author is mis-spelled, it should be "Costain" not "Constain".

Best regards

Alan Bridle

On Thu, June 24, 2021 8:49 am, Roland Timmerman wrote:
> Dear co-authors,
>
> We have received the second referee report for our paper on the rings of
> Hercules A. The referee (Geoff Bicknell) recommends publication after
> revision. This time, the referee report was a bit more detailed, and it
> reads a bit like he's agreeing to disagree. So, we're quite happy with
> the referee report, and we think our revisions should resolve the main
> issues that were raised.
>
> I have attached the referee report, our proposed reply, and the updated
> PDF of the paper with all corrections indicated in boldface to this
> email.
>
> We intend to resubmit the paper early next week. If you have any
> thoughts/comments/suggestions, we would love to hear them!
>
> Thank you all in advance.
>
> Cheers,
> Roland

From: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>
Subject: Hercules A - Second referee report
Date: Thu, June 24, 2021 8:49 am
To: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>
Cc: "Reinout van Weeren" <rvweeren@strw.leidenuniv.nl>,"Joe Callingham" <jcal@strw.leidenuniv.nl>,"William Cotton" <bcotton@nrao.edu>,"Rick Perley" <rperley@nrao.edu>,"Leah Morabito" <leah.k.morabito@durham.ac.uk>,"Nectaria Gizani" <ngizani@eap.gr>,"Alan Bridle" <abridle@nrao.edu>,"Christopher O'Dea" <Christopher.O'Dea@umanitoba.ca>,"Stefi Baum" <Stefi.Baum@umanitoba.ca>,"Grant Tremblay" <gtremblay@cfa.harvard.edu>,"Preeti Kharb" <kharb@ncra.tifr.res.in>,"Namir Kassim" <namir.kassim@nrl.navy.mil>,"Huub Rottgering" <rottgering@strw.leidenuniv.nl>,"Andrea Botteon" <botteon@strw.leidenuniv.nl>,"Frits Sweijen" <sweijen@strw.leidenuniv.nl>,cyril.tasse@obspm.fr,Marcus Brüggen <mbrueggen@hs.uni-hamburg.de>,"Javier Moldon" <jmoldon@iaa.es>,"Timothy Shimwell" <shimwell@strw.leidenuniv.nl>,"Gianfranco Brunetti" <brunetti@ira.inaf.it>

Dear co-authors,

We have received the second referee report for our paper on the rings of Hercules A. The referee (Geoff Bicknell) recommends publication after revision. This time, the referee report was a bit more detailed, and it reads a bit like he's agreeing to disagree. So, we're quite happy with the referee report, and we think our revisions should resolve the main issues that were raised.

I have attached the referee report, our proposed reply, and the updated PDF of the paper with all corrections indicated in boldface to this email.

We intend to resubmit the paper early next week. If you have any thoughts/comments/suggestions, we would love to hear them!

Thank you all in advance.

Cheers,
Roland

Attachments:

HercA_print_version_v3.pdf	
Size:	8.1 M
Type:	application/pdf

HercA_referee_reply.txt	
Size:	2.4 K
Type:	text/plain

HercA_referee_report.txt	
Size:	4.3 K
Type:	text/plain

Referee Report

The authors have attempted to address my point regarding adiabatic compression and shock waves. However, their statement:

Although it is an idealized assumption that the compression is adiabatic, this is a commonly employed assumption to study shock models in both Hercules A and other sources (e.g., Meier et al. 1991; Bruggen et al. 2007; Jubelgas et al. 2007). is misleading.

The authors are referring to hydrodynamic models in which shocks are modelled as discontinuities in the plasma in which both dissipation and adiabatic compression (not just the latter) are involved. The dissipation in these models is a way of allowing for the bulk effects of particle acceleration (i.e. the conversion of kinetic energy into internal energy), but the energy distribution of the particles is not addressed.

The main issue on which we disagree is whether the rings could be associated with shock waves induced by the jet's propagation in the turbulent cocoon backflow generated by the jet as proposed by Saxton et al. â€“ albeit using a non-relativistic simulation. The authors are more disposed to the idea, proposed by Gizani and Leahy, that the rings are the result of inner lobes produced by intermittent jet activity and they present a number of points to support this proposal.

However, in the discussion (section 4) the authors note that

"However, the inner-lobe model does have difficulty explaining the morphology of the rings. Inner lobes generally do not feature rim brightening, although this could at least partially be explained if the inner lobes are mainly filled with the Doppler-beamed jetted stream (Gizani & Leahy 2003)"

I find it difficult to see that Doppler beaming can rescue the situation since plasma should be decelerated at the shock produced by the inner lobe.

The authors are critical of the idea that the outer ring could be the result of an annular shock in view of its steep spectral index. However, in the Saxton at al. model the shocks are transient structures in which the transience is related to the turbulent backflow. Hence it is not difficult to conceive of a shock being formed transiently and then cool. The ring would then remain as a bright propagating feature starting to disperse into the backgound and with a steepening spectral index.

It appears to me that there are arguments both for and against the inner lobe and shock models but that in the light of the past and these new data, presented in this paper, the models are incomplete. Probably, the best way forward is for comprehensive MHD simulations to be undertaken relating to both scenarios in which the observations in this paper are taken into account. The authors could inform this process by setting out what features of the models and data need to be addressed.

One final point: In the Discussion section 4 the authors estimate the magnetic field from the Jaffe-Perola model with the input that the rings are propagating at the jet speed (0.8 c). The expression for hot spot (hence lobe) advance speed is given in equation (20) of Safouris et al. 2008 (MNRAS 385, 2117.). The hot spot advances at the jet speed only if the Lorentz factor is high. If this is what the authors are proposing they should state this.

Dear referee,

We thank you for your time and useful feedback. Below is our point-to-point reply to the comments from the referee report:

1. We have rephrased the conclusion to state that the spectral curvature measurements obtained from our observations are more consistent with an inner-lobe model, instead of the inner-lobe model being the preferred model in general. We also acknowledge that definitive evidence to settle the debate remains absent. These two changes aim to construct a more fair conclusion towards the shock model, as we agree with your argument that the inner-lobe model still struggles to provide a complete and compelling explanation for the observed ring structures.

2. We have added a paragraph suggesting that future research into the rings of Hercules A with MHD simulations could likely obtain that definitive evidence. Observationally, there are not many limitations we could improve on, so we agree that the logical next step is to investigate this from a more theoretical angle.

3. We have added two sentences about the magnetic field estimates, where we explain that we follow the assumption that the inner lobes propagate at the speed of the jets, which is a rough approximation. However, the goal of the calculation is only to test whether the resulting numbers are in a reasonable range. We appreciate the note about equation 20 from Safouris et al. (2008), but are also sceptical about implementing this in our calculation. The paper explains that this equation only holds when the momentum flux is not spread over a larger area than the jet cross-section, and this is not the case for the inner lobes in Hercules A.

We hope that this revision resolves the issues raised in the referee report, and look forward to your response.

Best regards,
Roland Timmerman

From: "Alan Bridle" <abridle@nrao.edu>
Subject: Re: Hercules A - Referee report
Date: Thu, May 13, 2021 10:17 pm
To: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>

Dear Roland

I think the referee should have gone with the option of requesting not to be the referee. As it stands, their report seems to be a lazy one critiquing the answer rather than the method. It is also inappropriate to ask for "substantial" but unspecified revisions.

I agree with the others that your response is perfectly appropriate. I think a careful editor might however suggest that someone else referee the paper before accepting it. However, we will not complain if they don't!

Best regards,

Alan

On Fri, May 7, 2021 10:50 am, Roland Timmerman wrote:
> Dear co-authors,
>
> We have received the referee report for our paper on the rings of
> Hercules A. The referee recommends publication after substantial
> revision. It is a quite weird referee report, so although we have done
> our best to prepare a reply, we would appreciate it if you could perhaps
> have a look as well to see if you have a better understanding of what
> the referee wants from us. As you can read, the referee sort of admits
> to being biased against our conclusions, and almost suggests requesting
> a different referee. For the moment, we think it's best to not play that
> card just yet, but instead to keep it as an option for the future.
>
> I have attached the referee report, our proposed reply, and the updated
> PDF of the paper with all corrections indicated in boldface to this
> email.
>
> We intend to resubmit the paper early next week. If you have any
> thoughts/comments/suggestions, we would love to hear them!
>
> Thank you all in advance.
>
> Cheers,
> Roland

From: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>
Subject: Hercules A - Referee report
Date: Fri, May 7, 2021 10:50 am
To: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>
Cc: "Reinout van Weeren" <rvweeren@strw.leidenuniv.nl>,"Joe Callingham" <jcal@strw.leidenuniv.nl>,"William Cotton" <bcotton@nrao.edu>,"Rick Perley" <rperley@nrao.edu>,"Leah Morabito" <leah.k.morabito@durham.ac.uk>,"Nectaria Gizani" <ngizani@eap.gr>,"Alan Bridle" <abridle@nrao.edu>,"Christopher O'Dea" <Christopher.O'Dea@umanitoba.ca>,"Stefi Baum" <Stefi.Baum@umanitoba.ca>,"Grant Tremblay" <gtremblay@cfa.harvard.edu>,"Preeti Kharb" <kharb@ncra.tifr.res.in>,"Namir Kassim" <namir.kassim@nrl.navy.mil>,"Huub Rottgering" <rottgering@strw.leidenuniv.nl>,"Andrea Botteon" <botteon@strw.leidenuniv.nl>,"Frits Sweijen" <sweijen@strw.leidenuniv.nl>,cyril.tasse@obspm.fr,Marcus Brüggen <mbrueggen@hs.uni-hamburg.de>,"Javier Moldon" <jmoldon@iaa.es>,"Timothy Shimwell" <shimwell@strw.leidenuniv.nl>,"Gianfranco Brunetti" <brunetti@ira.inaf.it>

Dear co-authors,

We have received the referee report for our paper on the rings of Hercules A. The referee recommends publication after substantial revision. It is a quite weird referee report, so although we have done our best to prepare a reply, we would appreciate it if you could perhaps have a look as well to see if you have a better understanding of what the referee wants from us. As you can read, the referee sort of admits to being biased against our conclusions, and almost suggests requesting a different referee. For the moment, we think it's best to not play that card just yet, but instead to keep it as an option for the future.

I have attached the referee report, our proposed reply, and the updated PDF of the paper with all corrections indicated in boldface to this email.

We intend to resubmit the paper early next week. If you have any thoughts/comments/suggestions, we would love to hear them!

Thank you all in advance.

Cheers,
Roland

Attachments:

HercA_print_version_v2.pdf	
Size:	8.1 M
Type:	application/pdf

HercA_proposed_reply.txt	
Size:	4.3 k
Type:	text/plain

HercA_referee_report.txt	
Size:	3.1 k
Type:	text/plain

Referee Report

This paper presents an interesting synthesis of observations of the iconic radio galaxy, Hercules A, using the LOFAR and JVLA radio telescopes. The observations show the added value of low frequency imaging in this field.

It has been long known that Hercules A exhibits intriguing ring structures in the Western lobe for which there are two main models, to which the authors refer as a "shock model" and an "inner lobe" model. In the shock model the jet encounters irregularities in the Western lobe related to entrained ambient gas and this produces annular shocks. The inner lobe model involves spherical bubbles caused by previous outbursts of the central source. These are then filled in by a later outburst, leading to edge brightened structures which appear as rings. The shock model has been simulated by Saxton et al. (2002), providing synthetic surface brightness images. As far as I am aware, there has been no corresponding simulation of the inner lobe model.

The authors examine the viability of these models, mainly based upon the spectral index structure, revealed by the wide wavelength coverage of their observations. They conclude that the inner lobe model is the more likely.

However, I must state that I find their conclusion unappealing. Part of the argument is based upon the flat spectral index ~ -0.8 of the rings, with the spectral index likely to be even flatter, given the overlying steep spectral index of the lobe. This pushes the spectral index close to the value ~-0.6 associated with strong shocks in nonthermal plasma â€“ consequently strongly favouring the shock model. Another incidental point: The authors discuss shocks produced by adiabatic compression. In fact, shocks are not adiabatic.

The authors also present evidence that each consecutive ring, counting from the core, shows more spectral steepening using rigorous data analysis to demonstrate this. However, in the context of the shock model, this could simply imply that the outer ring is the older. This may be the case, if, for instance, the inner rings are associated with more recent jet outbursts.

Since I am one of the authors of the Saxton et al. paper, I can understand perfectly that the authors may wish to ask for a different referee. However, I do think that they need to address the above points.

Dear referee,

We thank you for your time and feedback. We appreciate your openness about your position. Below is our point-to-point reply to the comments from the referee report:

1. The first point of feedback is that the rings are observed to feature a spectral index of around -0.8 (likely steeper due to steep line-of-sight lobe material), and that this spectral index is in fact consistent with a shock model. We do agree with the fact that a spectral index of -0.8 (or flatter) does not argue against a shock model. However, the argument from Gizani et al. (2003), is that the differences between the spectral indices of the rings are peculiar. Gizani et al. state that the shock model would require a significant amount of particle acceleration to obtain a spectral index of -0.8. However, it is then difficult to explain why the outermost ring features such a steep spectral index, and thus low amount of particle acceleration, even though it appears like it should be the strongest shock. For the sake of informing the reader about the ongoing discussion about the nature of the rings and the arguments that have been presented, we include this argument in our introduction and later in the discussion section. However, it is not an original argument presented in this paper. We have clarified this argument in our manuscript by emphasizing that the relation between the spectral indices is addressed in this argument, and by removing the distracting spectral index values from the introduction.

2. We appreciate the point about shocks not being adiabatic. First of all, we clarify our statement of shocks produced by adiabatic compression, which was misleading. Naturally, compression and particle acceleration are induced by the presence of a shock wave, not the other way around. Secondly, we have added a sentence in the manuscript conceding that the assumption of adiabatic compression is idealized, although it is also a generally accepted assumption in the case of shock waves (see, e.g., Meier et al. (1991) in the case of Hercules A).

3. The third point of feedback is that the trend of increasing spectral curvature as the rings are further away from the AGN can also be interpreted as being caused by old shocks. We are confused as to how we should imagine such a model based on old shocks. Shock waves should be an active site of compression and particle acceleration, and we are able to spatially separate the shock front from the shock downstream region. At the shock, one would expect a power-law spectrum with the spectral steepening/curvature occurring only in the downstream region. Therefore, we find it difficult to understand how our detection of spectral curvature at the position of the rings could be matched with such a model. We would like to emphasize that we do not exclude the shock model as a possibility in our conclusions, but only state that our measurements appear to give preference to an inner-lobe model.

We do not think our current revision of the manuscript can be considered to be â€œsubstantialâ€, and therefore request a more detailed summary of which points we should address, if the current manuscript is not considered to be ready for publication yet.

Best regards,
Roland Timmerman

From: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>
Subject: Re: New draft on Hercules A - co-authorship
Date: Mon, February 22, 2021 9:26 am
To: abridle@nrao.edu

Dear Alan,

Thank you very much! Can I assume you're happy to join the paper?

Cheers,
Roland

On 2021-02-20 05:22, Alan Bridle wrote:
> Dear Roland
>
> Thank you for looking into that and confirming. It will be worth
> saying that
> tests were done to ensure that the spectral curvature is real, to head
> off
> questions of the sort that I had.
>
> It's a good result.
>
> Best regards,
>
> Alan
>
>
>
> On Wed, February 17, 2021 4:53 pm, Roland Timmerman wrote:
>> Dear Alan,
>>
>> I have checked with Bill, and unfortunately he does not have the
>> uv-matched images anymore. It seems they were lost in a disk failure,
>> so
>> we have to make do with the VLA images we currently have. Fortunately,
>> we do have uv-matched LOFAR images to both the VLA L- and C bands
>> individually, and those give very consistent results.
>>
>> We currently have multiple reasons to believe that our spectral
>> curvature measurements are valid. First of all, applying a lower limit
>> on the baseline length to match the C-band observations would only
>> reduce the largest angular scale to which the data are sensitive to
>> 4.2
>> arcminutes, which still exceeds the maximum angular extent of Hercules
>> A
>> by an arcminute. This means that the spectral curvature trends within
>> Hercules A are highly unlikely to be caused by bowl effects, and also
>> means that the background subtraction method is still reliable as
>> well.
>> Secondly, by inspection of the maps, we do not detect any significant
>> bowl artifacts in the region surrounding Hercules A, so it is highly
>> unlikely that this effect significantly affects our measurements.
>> Finally, as I mentioned before, we do have uv-matched LOFAR maps to
>> both
>> the L and C bands individually. Even in just the LOFAR-C band spectral
>> index map, the trend of the increasing steepening is visible. In
>> addition, we can actually confirm that the spectral curvature
>> measurements are also reliable, because we can derive the L band to C
>> band spectral indices based on the uv-matched LOFAR to L band spectral
>> indices and the LOFAR to C band spectral indices. This only requires
>> that the LOFAR measurements are internally consistent, and do not vary
>> significantly depending on whether the LOFAR map is matched to the L
>> band or to the C band. Fortunately, we can confirm that this is indeed
>> the case, so we can be confident in the validity of our spectral
>> curvature measurements.
>>
>> In the draft, we have elaborated on how we have produced the spectral
>> index maps.
>>
>> Cheers,
>> Roland
>>
>> On 2021-02-12 00:23, Alan Bridle wrote:
>>> Dear Roland
>>>
>>> Let's see how the spectral analysis stands up with the data matched
>>> in
>>> the
>>> u,v plane. If looking at them that way indeed gives the same answer
>>> and
>>> everyone is happy that there are no bowl effects at C Band at a level
>>> that
>>> could affect the spectral curvature result, I'll be happy to be on
>>> the

From: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>
Subject: Re: New draft on Hercules A - co-authorship
Date: Wed, February 17, 2021 4:53 pm
To: abridle@nrao.edu

Dear Alan,

I have checked with Bill, and unfortunately he does not have the uv-matched images anymore. It seems they were lost in a disk failure, so we have to make do with the VLA images we currently have. Fortunately, we do have uv-matched LOFAR images to both the VLA L- and C bands individually, and those give very consistent results.

We currently have multiple reasons to believe that our spectral curvature measurements are valid. First of all, applying a lower limit on the baseline length to match the C-band observations would only reduce the largest angular scale to which the data are sensitive to 4.2 arcminutes, which still exceeds the maximum angular extent of Hercules A by an arcminute. This means that the spectral curvature trends within Hercules A are highly unlikely to be caused by bowl effects, and also means that the background subtraction method is still reliable as well. Secondly, by inspection of the maps, we do not detect any significant bowl artifacts in the region surrounding Hercules A, so it is highly unlikely that this effect significantly affects our measurements. Finally, as I mentioned before, we do have uv-matched LOFAR maps to both the L and C bands individually. Even in just the LOFAR-C band spectral index map, the trend of the increasing steepening is visible. In addition, we can actually confirm that the spectral curvature measurements are also reliable, because we can derive the L band to C band spectral indices based on the uv-matched LOFAR to L band spectral indices and the LOFAR to C band spectral indices. This only requires that the LOFAR measurements are internally consistent, and do not vary significantly depending on whether the LOFAR map is matched to the L band or to the C band. Fortunately, we can confirm that this is indeed the case, so we can be confident in the validity of our spectral curvature measurements.

In the draft, we have elaborated on how we have produced the spectral index maps.

Cheers,
Roland

On 2021-02-12 00:23, Alan Bridle wrote:
> Dear Roland
>
> Let's see how the spectral analysis stands up with the data matched in
> the
> u,v plane. If looking at them that way indeed gives the same answer
> and
> everyone is happy that there are no bowl effects at C Band at a level
> that
> could affect the spectral curvature result, I'll be happy to be on the
> paper
> as a co-author and thank you for keeping me in the loop. I have
> wondered
> about this source since I saw the first VLA images of it back in the
> 1980's so
> it would be nice to be associated with moving a little further forward
> towards
> an explanation for the unusual structure.
>
> I will look forward to seeing the next draft,
>
> With best regards
>
> Alan Bridle
>
> On Thu, February 11, 2021 11:00 am, Roland Timmerman wrote:
>> Dear Alan,
>>
>> Thank you very much for your excellent feedback!
>>
>> For this paper we are strongly building on the unpublished results of
>> the VLA project from 2012. We have added new LOFAR observations, but
>> it
>> is also in part a revival of that old project. Your involvement with
>> the
>> original VLA project and your helpful feedback on this paper
>> absolutely
>> justifies you as a co-author on this paper, in my opinion. If you are
>> happy to join the paper, we would be pleased to have you.
>>
>> The spectral index maps were indeed obtained by bringing the different
>> maps to a common resolution. We were indeed not clear about this, and

From: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>
Subject: Re: New draft on Hercules A - co-authorship
Date: Thu, February 11, 2021 11:00 am
To: abridle@nrao.edu

Dear Alan,

Thank you very much for your excellent feedback!

For this paper we are strongly building on the unpublished results of the VLA project from 2012. We have added new LOFAR observations, but it is also in part a revival of that old project. Your involvement with the original VLA project and your helpful feedback on this paper absolutely justifies you as a co-author on this paper, in my opinion. If you are happy to join the paper, we would be pleased to have you.

The spectral index maps were indeed obtained by bringing the different maps to a common resolution. We were indeed not clear about this, and will clarify this in the draft. Initially, we simply achieved this via convolution. However, your point that the different maps should be filtered to the same u-v range is of course correct. This week we produced new LOFAR maps of Hercules A for the spectral index mapping, but then with the same u-v range as the VLA maps. I know that Rick and Bill produced spectral index maps between the VLA maps, which I assume they matched in uv-range. I'll double check with them and try to obtain those maps so the VLA maps are consistent between each other as well. If we can recover those, we will have identical uv-ranges in each of the three frequency bands. Based on the spectral index maps provided in the VLA draft, the results appear to be consistent, so I don't expect any significant changes to the results. However, it would indeed be good to confirm this. The new uv-matched LOFAR maps are also entirely consistent with the previous results, so that is already promising. I will elaborate on all of this in the draft, because it is indeed very important for the validity of the spectral index maps.

Again, thank you very much for your comments.

Best regards,
Roland

On 2021-02-05 21:26, Alan Bridle wrote:
> Dear Roland
>
> Thank you for letting me see the new results. I am retired from the
> NRAO
> as an active staff member now but I remain associated with them and I
> remain
> very interested in Hercules A. Whether I can contribute meaningfully
> to this
> paper and justify being a co-author on it remains to be seen, however.
>
> I have taken a look at it some comments follow.
>
> The LOFAR image is very interesting despite some deconvolution
> artifacts and
> the analysis definitely benefits from the wide frequency range that is
> now
> available.
>
> One aspect of the presentation confuses me a little, however. The
> angular
> resolutions of the images shown at the three frequencies are very
> different,
> and the lower resolution of the VLA L Band data is particularly
> striking.
> I presume the spectral index images are at that resolution but they do
> not say
> so. The question that bothered me was "how were the data brought to a
> common
> resolution for the spectral analysis and what do the images look like
> at that
> resolution?"
>
> Was the common resolution achieved by filtering in the u,v plane
> or by convolution? Is the relative sensitivity to the rings the same
> at all
> three frequencies on all scales? And is the zero level of the images
> on all
> scales well established? This is especially important as the spectral
> curvature shown in Fig.3 seems to be highest at the edges of the source
> -
> which is a distribution that could be an artifact of a "bowl" resulting
> from
> missing short spacings at the highest frequency.
>

From: "Alan Bridle" <abridle@nrao.edu>
Subject: Re: New draft on Hercules A - co-authorship
Date: Fri, February 5, 2021 8:26 pm
To: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>

Dear Roland

Thank you for letting me see the new results. I am retired from the NRAO as an active staff member now but I remain associated with them and I remain very interested in Hercules A. Whether I can contribute meaningfully to this paper and justify being a co-author on it remains to be seen, however.

I have taken a look at it some comments follow.

The LOFAR image is very interesting despite some deconvolution artifacts and the analysis definitely benefits from the wide frequency range that is now available.

One aspect of the presentation confuses me a little, however. The angular resolutions of the images shown at the three frequencies are very different, and the lower resolution of the VLA L Band data is particularly striking. I presume the spectral index images are at that resolution but they do not say so. The question that bothered me was "how were the data brought to a common resolution for the spectral analysis and what do the images look like at that resolution?"

Was the common resolution achieved by filtering in the u,v plane or by convolution? Is the relative sensitivity to the rings the same at all three frequencies on all scales? And is the zero level of the images on all scales well established? This is especially important as the spectral curvature shown in Fig.3 seems to be highest at the edges of the source - which is a distribution that could be an artifact of a "bowl" resulting from missing short spacings at the highest frequency.

I am not saying that this IS the reason for the observed effect, just that a concentration of the spectral curvature towards the edge of the source could come partly from a frequency dependent bowl arising from different sampling of the u.v plane at different frequencies. It would be good to convince the reader somehow that this is not the case. Perhaps it is obvious from directly inspecting the input data to the spectral index analysis. But if so that might be spelled out in the paper to reassure the readers, even by directly showing those data as well as the higher resolution images..

A minor point on the graphics. The lines identifying the rings in Fig. 1 all terminate in the fainter lobe emission and thus do not directly identify the rings themselves. It is still obvious which ring is the innermost and the middle which but there is what looks like edge brightening on the lobe at L Band which looks very like yet another "ring" beyond the "outermost" in the LOFAR image. When I first looked at Fig.1 the labeling of the "outermost" ring on the C Band image did not make it immediately clear which feature is "outermost" because the line points to the space between the two features.

The fact that there is noticeable emission beyond the "very outermost" ring on the LOFAR and L Band images but not in the C Band image does raise some questions about sensitivity of the three images to the largest scale of the emission, or alternatively to whether any residual "bowl effects" are present in the C Band image and whether those could contribute to the apparent spectral curvature.

Overall , it is a good paper and a interesting result but perhaps just a little more needs to be presented to convince the reader that the spectral curvature result is entirely real with no contribution from differences in u,v sampling at the different frequencies.

The "background subtracted" analysis deals with this to some extent, but I feel that the readers who are most familiar with spectral artifacts in interferometric imaging might still need a little more assurance that the curvature distribution is real.

With best regards

Alan Bridle

.

C Band image
On Wed, February 3, 2021 2:29 pm, Roland Timmerman wrote:
> Dear all,
>
> I hope this email finds you well. My name is Roland Timmerman, and I am
> a PhD student at the Leiden Observatory. We have just completed a draft
> for a paper on the rings in Hercules A using new LOFAR observations and
> VLA observations from 2012 which were shared with us by Rick Perley and

> Bill Cotton. As you were all involved in the VLA project, we would like
> to invite you to also join this new paper. If you would like to join the
> paper, please confirm your affiliation(s) and let me know if there are
> any acknowledgements we should add. Also, if you have any feedback or
> comments on the draft, we would very much appreciate to hear it.
>
> The draft can be accessed via the following link:
>
> https://www.overleaf.com/5828914251cqgrdhwmxpdt
>
> Title: Origin of the ring structures in Hercules A -- sub-arcsecond 144
> MHz to 7 GHz observations
>
> Abstract:
> The prominent radio source Hercules A features complex structure in its
> radio lobes. Despite being one of the most well-studied sources in the
> radio sky, the origin of the ring structures in its radio lobes remains
> an open question. We present the first sub-arcsecond angular resolution
> observations at low-frequencies (<300 MHz) of Hercules A by the
> International LOFAR Telescope, as well as images using data from the
> Karl G. Jansky Very Large Array, allowing the structure of the lobes to
> be studied between 144 MHz to 7 GHz in detail. We explore the origin of
> the rings within the lobes of Hercules A, and test whether these rings
> are best described by a shock model or an inner-lobe model, where the
> rings are formed by decelerated jetted plasma. Through spectral index
> mapping, we exploit the large frequency coverage and find that each of
> the rings features an increasingly curved spectrum as the rings are
> farther away from the central active galactic nucleus (AGN). We suggest
> that the spectral shape of the rings is consistent with synchrotron
> ageing, indicating that the rings are most likely formed from the
> deposition of material from past periods of intermittent core-activity.
>
> I look forward to hearing from you.
>
> Best regards,
> Roland Timmerman
> PhD Candidate, Leiden Observatory
>

From: "Roland Timmerman" <rtimmerman@strw.leidenuniv.nl>
Subject: New draft on Hercules A - co-authorship
Date: Wed, February 3, 2021 2:29 pm
To: manitoba.ca,gtremblay@cfa.harvard.edu,kharb@ncra.tifr.res.in,namir.kassim@nrl.navy.mil,ngizani@eap.gr,"Reinout van Weeren" <rvweeren@strw.leidenuniv.nl>

Dear all,

I hope this email finds you well. My name is Roland Timmerman, and I am a PhD student at the Leiden Observatory. We have just completed a draft for a paper on the rings in Hercules A using new LOFAR observations and VLA observations from 2012 which were shared with us by Rick Perley and Bill Cotton. As you were all involved in the VLA project, we would like to invite you to also join this new paper. If you would like to join the paper, please confirm your affiliation(s) and let me know if there are any acknowledgements we should add. Also, if you have any feedback or comments on the draft, we would very much appreciate to hear it.

The draft can be accessed via the following link:

https://www.overleaf.com/5828914251cqgrdhwmxpdt

Title: Origin of the ring structures in Hercules A -- sub-arcsecond 144 MHz to 7 GHz observations

Abstract:
The prominent radio source Hercules A features complex structure in its radio lobes. Despite being one of the most well-studied sources in the radio sky, the origin of the ring structures in its radio lobes remains an open question. We present the first sub-arcsecond angular resolution observations at low-frequencies (<300 MHz) of Hercules A by the International LOFAR Telescope, as well as images using data from the Karl G. Jansky Very Large Array, allowing the structure of the lobes to be studied between 144 MHz to 7 GHz in detail. We explore the origin of the rings within the lobes of Hercules A, and test whether these rings are best described by a shock model or an inner-lobe model, where the rings are formed by decelerated jetted plasma. Through spectral index mapping, we exploit the large frequency coverage and find that each of the rings features an increasingly curved spectrum as the rings are farther away from the central active galactic nucleus (AGN). We suggest that the spectral shape of the rings is consistent with synchrotron ageing, indicating that the rings are most likely formed from the deposition of material from past periods of intermittent core-activity.

I look forward to hearing from you.

Best regards,
Roland Timmerman
PhD Candidate, Leiden Observatory
