From gmoellen@aoc.nrao.edu Tue Sep 9 17:45:55 2014
Date: Tue, 9 Sep 2014 09:45:14 -0600
From: George Moellenbrock <gmoellen@aoc.nrao.edu>
To: Rosita Paladino <paladino@ira.inaf.it>
Cc: Catherine Vlahakis <cvlahaki@alma.cl>, marcelino <marcelino@ira.inaf.it>, Hiroshi N
AGAI <hiroshi.nagai@nao.ac.jp>, Kouichiro Nakanishi <knakanis@alma.cl>, Ed Fomalont <ef
omalon@nrao.edu>, Arturo Mignano <amignano@ira.inaf.it>, Martin Zwaan <mzwaan@eso.org>
Subject: Re: Polarization Science Verification data / CASA guide

Hi Rosita-

The parang issue is a subtle one.Â It took me a bit of time
to think it through.Â Â Basically, it is a matter
of what happens when correcting D-corrupted data with parang:

(read with a fixed-width font, so the equations look right)

For the linear feed basis, the P matrix (per antenna) is a
rotation matrix that mixes orthogonal linear
polarization voltages:

```
[cos xÂ Â  sin x]
[-sin xÂ  cos x]
```

...where x is the parallactic angle, and for ALMA, x is ~same
for all antennas at each timestamp.Â (For VLBI, they will be \
quite different.)Â Â I will abbreviate the P matrix as:

```
[cÂ  s]
[-s c]
```

...and assume it is the same for all antennas.

When we corrupt a general polarized model, we apply this
kind of matrix for both antennas in each baseline, we get
corrupted visibilities, V:

V =Â PMPtÂ Â Â Â (where Pt is the transpose of P for the 2nd antenna)

So, for

```
M=[XX XY] = [I+Q U+iV]
Â  [YX YY] Â  [U-iV I-Q],
```

our P-corrupted model is:

```
V = [cÂ  s] [I+Q U+iV] [c -s]
Â Â Â  [-s c] [U-iV I-Q] [sÂ  c]

Â  = [I+Qcos2x+Usin2xÂ  -Qsin2x+Ucos2x+iV]Â Â  (for x const over ants)
Â  Â  [-Qsin2x+Ucos2x-iVÂ  I-Qcos2x-Usin2x]

Â  = [I+Qu -Uq+iV]Â Â Â  (Qu = Qcos2x+Usin2x)
Â Â Â  [-Uq-iV I-Qu]Â Â Â  (Uq = Qsin2x+Ucos2x)

Â  = [I 0]Â Â Â  (for Q=U=V=0)
Â Â Â  [0 I]
```

...i.e., the P matrices effectively behave as unit matrices if
Q=U=V=0.Â (Actually, the x are only approx constant over antennas,
so there is a slight difference, but it is very small.)

So, when solving for the gains from observed visibilities, V, the _mnemonic_ operator equation is:

V = G (PM)Â Â Â (solving for G)

(This is an operator equation, as in my lecture slides, not really a matrix equation.Â 'PM' means 'PMPt', and G(...) represents the operation of both antennas' Gs on the (...). I could instead write the rigorous matrix equation:

V = G(PMPt)GtÂ (solving for G)

...but I think this would be more confusing in my talk. The mnemonic operator expressions are a shorthand for the real matrix algebra.)

So, the P corruption of M has no effect if Q=U=V=0 inside M.Â Â You should get the same G with parang=T or parang=F.Â Â (Actually, since the x are only approximately constant over antennas, there may be a very small difference.)

However, when _correcting_ the observed visibilities, V:

C = P'(G'VGt')Pt'Â Â Â (primes mean inverses)

...the G correction is good, because the G solution was good, but since M contains D-corrupted information in the cross-hands, that corrupted stuff will get mixed with the parallel hands (note the sign of the sin terms has been reversed by doing the inverse of the Ps):

```
C = P' VgÂ  Pt'
Â  = [c -s] [I+Qu+junk1Â  -Uq+iV+junk2] [cÂ  s]
Â Â Â  [sÂ  c] [-Uq-iV+junk3Â  I-Qu+junk4] [-s c]

Â  = [(I+Q)+f1(junk*) (U+iV)+f2(junk*)]
Â  Â  [(U-iV)+f3(junk*) (I-Q)+f4(junk*)]Â
```

The functions, fi, are different functions of all four junki, and the parallactic angles.Â The junki are terms containing the D-terms.Â Â There is some symmetry in the junki and fi, but not perfect since the Ds for each antenna are different.

Now, junk1 and junk4 are dominated by things proportional to the linear polarization and the D-terms, and junk2 and junk3 are dominated by things proportional to total intensity and the D-terms.Â If the D-terms are small, then we can usually tolerate the junk1 and junk4 terms in the parallel hands, since they are a few % (D) times a few % (Q and U) of I. (And note that any real Q will cancel when forming I=(XX+YY)/2.) However, including the P correction causes junk2 and junk3 to enter the parallel hands via f1 and f4, and so we get terms a few % (D) of I.Â This is worse.Â Â Since the Ds are strongly freq-dep, note that this will cause freq-dep in the parallel hands.Â If the Ds are very small, this may be ok, but in general, until the D-terms are solved, and the junki properly modeled and corrected, the parallactic angle correction should be avoided. Note that if the Ds are absolute, junk1 and junk4 will also be properly corrected.Â

Now for the circular feed basis, the P matrix has phase rotation terms on the diagonal, and zeros off the diagonal, so when using parang=T, there is _never_ any mixing of the cross-hands with the parallel hands.Â In that case, things are a bit simpler.

Does that make sense?

Cheers,
George

On Tue, Sep 9, 2014 at 8:15 AM, Rosita Paladino <paladino@ira.inaf.it> wrote:

Hi George,
thank you.

We discussed about the exact point you raised, indeed.
I got really confused with the parang parameter, actually, and we planned to discuss about it in details via email.
We will appreciate your contribution whenever you will have time.

In the normal non-pol calibration we use the default: parang=F.
That’s why I added a note on the need to explain why in this case we use parang=T for the non-pol calibrators. Hiroshi and Ed already told me that for this gaincal it does’nt matter, since here we are not using a full stokes model in the gaincal. I will remove it!

Still, it is not clear to me why then when we apply only Bscan and G2
to the fields, the results are different if using parang=T or F. The gains
should be correct if parang only matters when the cross-hand model is non zero, so why the application with parang=F seems to be the wrong one?
(Just above the Polarization Calibration section there are some plots showing the tests I made)

I surely need to think more about this parang...

Thank you very much,
Rosita

On Tue, 9 Sep 2014, George Moellenbrock wrote:

All-

I am very sorry I missed today’s telecon.Â I got the time
wrong.

I’ve only had time to briefly look over the
3C286_Band6Pol_Calibration_for_CASA_4.2
page, and my impression is that things are generally working.Â

The one thing that raises a question in my view is use of
parang=T _prior_
to the
polarization calibration part.Â Â Note that application of the
parang
correction
re-mixes cross and parallel hands.Â Â In the various gain and
bandpass
solving
parts, this doesn’t matter because the cross-hand _model_ is
zero, but in

the applycal, this causes D-corrupted cross-hands to be mixed
with the
reasonably calibrated parallel hands.Â This is probably not
ideal. Â Is this
used in ordinary non-poln reductions?

I am fairly busy with the end of the CASA 4.3 dev cycle at the
moment (esp.
this
week), but if there are additional questions, please ask and
I’ll do my best
to reply
as soon as possible....

Again, sorry I missed the meeting.

Cheers,
George
Â Â

On Sun, Sep 7, 2014 at 1:44 PM, Catherine Vlahakis
<cvlahaki@alma.cl> wrote:
Â Â Â Hi everyone,

This is just to confirm that the telecon will be on 9 Sept at
12 UT.

We’ll try skype first (I will hopefully be able to initiate
the call,
but in case not - Ed, can you make sure you have everyone’s
skype
details - ask me if not)? If skype doesn’t work for some of us
(most
likely me, since I’ll be travelling) we can also use the
phone. Phone
details are:
Â *Â For Chile: 800 532833
Â *Â For Germany: 08001014529
Â *Â For US: 8005048071
Â *Â For Japan: 00531001557
Â *Â For Netherlands: 08002658226
Â *Â For UK: 0800 496 0579
Â *Â For France: 800941634
Â *Â For Taiwan: 0809092289
Â *Â For Italy: 800182599
Â *Â Participant access code of this teleconference: 4676128#

Talk to you then,

Cheers,

Cat

On Fri, Sep 5, 2014 at 5:43 AM, Catherine Vlahakis
<cvlahaki@alma.cl>
wrote:
Â Â Â Hi all,

OK, then 12 UT on Tuesday? Ed, this should be 9am for you since
we are changing the clocks in Chile before then.

Can everyone do phone as well as skype? I’ll set up both, since
I’m not sure how well skype will work for me next week when I’m
travelling. Ed, will skype work for you? Let’s try it out on
Monday.

C

On Fri, Sep 5, 2014 at 5:35 AM, Rosita Paladino
<paladino@ira.inaf.it> wrote:

Â Â Â Hi Cat,
Â Â Â Tuesday or Wednesday is fine with me!

Â Â Â Actually, since I would like to have a consistent
Â Â Â part of the casaguide about the theoretical
Â Â Â explanation (I do’nt know if you agree) I would like
Â Â Â to have Ed contribution, if possible.

Â Â Â Thank you,
Â Â Â Rosita

Â Â Â On Fri, 5 Sep 2014, Catherine Vlahakis wrote:

Â Â Â Hi everyone,

Â Â Â Due to the conflicting calibrator meeting I
Â Â Â think we need to postpone the
Â Â Â polarization SV meeting until next week. Let’s
Â Â Â try to arrange something
Â Â Â then. How about Tuesday or Wednesday 9/10
Â Â Â Sept? Or Monday 15th?

Â Â Â Ed, I don’t think this meeting is that
Â Â Â relevant for you so it shouldn’t
Â Â Â matter about a conflict with your long
Â Â Â baselines meetings, but let me know
Â Â Â if you do want to come to this so we can
Â Â Â schedule an appropriate time for
Â Â Â all.

Â Â Â Cheers,
Â Â Â Cat

Â Â Â On Thu, Sep 4, 2014 at 5:24 AM, marcelino
Â Â Â <marcelino@ira.inaf.it> wrote:
Â Â Â Â Â Â Hi Cat,

Â Â Â Â Â Â I’m attending the calibrator meeting on
Â Â Â friday.
Â Â Â Â Â Â If possible please find another time,
Â Â Â otherwise Rosita is
Â Â Â Â Â Â available for this meeting.

Â Â Â Â Â Â Thanks,
Â Â Â Â Â Â Nuria

Â Â Â Â Â Â On 2014-09-04 06:32, Catherine Vlahakis
Â Â Â wrote:
Â Â Â Â Â Â Hi Nagai-san,

Â Â Â Â Â Â Thanks.

Â Â Â Â Â Â For those of you in Santiago, there is a
Â Â Â calibrator
Â Â Â Â Â Â meeting at the
Â Â Â Â Â Â same time of 9am on Friday - does that
Â Â Â pose a conflict for
Â Â Â Â Â Â any of you?
Â Â Â Â Â Â If so, let me know and we can try for
Â Â Â another time on
Â Â Â Â Â Â Friday.

Â Â Â Â Â Â Cheers,
Â Â Â Â Â Â Cat

Â Â Â Â Â Â On Thu, Sep 4, 2014 at 12:29 AM, Hiroshi
Â Â Â NAGAI
Â Â Â Â Â Â <hiroshi.nagai@nao.ac.jp> wrote:

Â Â Â Â Â Â Hi Cat and all,

Â Â Â Â Â Â Friday is fine for me.
Â Â Â Â Â Â Sorry for my slow response.

Â Â Â Â Â Â Best,
Â Â Â Â Â Â Hiroshi

Â Â Â Â Â Â (2014/09/03 18:07), Kouichiro Nakanishi
Â Â Â wrote:
Â Â Â Â Â Â Hi Cat and all,

Â Â Â Â Â Â I’m able to join the meeting on Friday,
Â Â Â probably.
Â Â Â Â Â Â Hiroshi is on vacation now and he may
Â Â Â wish to have
Â Â Â Â Â Â the telecon next week. Could you wait a
Â Â Â bit before
Â Â Â Â Â Â he make response? Thanks for your
Â Â Â understanding.

Â Â Â Â Â Â cheers,
Â Â Â Â Â Â Kouichiro

Â Â Â Â Â Â (2014/09/02 17:47), Catherine Vlahakis
Â Â Â wrote:
Â Â Â Â Â Â Hi Rosita, Arturo and Nuria,

Â Â Â Â Â Â Thanks for all your efforts on this!
Â Â Â Yes, I think we can
Â Â Â Â Â Â try to schedule
Â Â Â Â Â Â a telecon this week. Friday would be the
Â Â Â best option from
Â Â Â Â Â Â my side.13:00
Â Â Â Â Â Â UT again?

Â Â Â Â Â Â Nakanishi-san, I know you are in Japan
Â Â Â right now (well,

Â Â Â Â Â Â actually
Â Â Â Â Â Â probably still on your way!), so I don’t
Â Â Â know whether you
Â Â Â Â Â Â are able to
Â Â Â Â Â Â join on Friday. If not, and you’d like
Â Â Â to have the telecon
Â Â Â Â Â Â next week
Â Â Â Â Â Â instead, please let me know. Next week I
Â Â Â may not be able
Â Â Â Â Â Â to attend though.

Â Â Â Â Â Â Thanks,
Â Â Â Â Â Â Cat

Â Â Â Â Â Â On Tue, Sep 2, 2014 at 12:27 PM, Rosita
Â Â Â Paladino
Â Â Â Â Â Â <paladino@ira.inaf.it
Â Â Â Â Â Â <mailto:paladino@ira.inaf.it>> wrote:

Â Â Â Â Â Â Â Â Dear all,

Â Â Â Â Â Â Â Â we started working on the casaguide.
Â Â Â Â Â Â Â Â We have here a wiki page where we
Â Â Â could create a
Â Â Â Â Â Â private link,
Â Â Â Â Â Â Â Â accessible only with credentials, we
Â Â Â wrote our draft
Â Â Â Â Â Â here to avoid
Â Â Â Â Â Â Â Â the "public" casaguide website.

Â Â Â Â Â Â Â Â You can access it using:
Â Â Â Â Â Â Â Â username= almauserN
Â Â Â Â Â Â Â Â password= almaNpasswd
Â Â Â Â Â Â Â Â with N in the range from 0 to 29.

Â Â Â Â Â Â Â Â The main page is just the copy of
Â Â Â N3256 casaguide and
Â Â Â Â Â Â needs to be :
Â Â Â Â Â
Â Â Â http://www.alma.inaf.it/index.__php/Private:3C286_Casaguide
Â Â Â [1]
Â Â Â Â Â
Â Â Â <http://www.alma.inaf.it/index.php/Private:3C286_Casaguide
Â Â Â [2]>
Â Â Â Â Â The calibration part is here:
Â Â Â
Â Â http://www.alma.inaf.it/index.__php/3C286_Band6Pol___Calibration_for_CASA_
Â Â Â 4
Â Â Â .2 [3]
Â Â Â Â Â
Â Â Â
<http://www.alma.inaf.it/index.php/3C286_Band6Pol_Calibration_for_CASA_4.2
Â Â Â [4]>

Â Â Â Â Â The first part of the calibration is done
Â Â Â running cycles
Â Â Â over the
Â Â Â Â Â different datasets. We still need to add
Â Â Â figures and
Â Â Â details. One
Â Â Â Â Â thing we would like to know is how deep we
Â Â Â should go into
Â Â Â the

```
Â  Â  Â  Â  Â  explanation of casa details for the
Â  Â  Â  "normal" calibration
Â  Â  Â  part. Could
Â  Â  Â  Â  Â  we refer to other casaguides, or this
Â  Â  Â  should be
Â  Â  Â  self-consistent?
Â  Â  Â  Â  Â  Things that need to be added, or which we
Â  Â  Â  are not sure
Â  Â  Â  about, are
Â  Â  Â  Â  Â  written in bold.

Â  Â  Â  Â  Â  For the polarization calibration part we
Â  Â  Â  need some help.
Â  Â  Â  Â  Â  Here is a summary of the most critical
Â  Â  Â  parts where we need
Â  Â  Â  some more
Â  Â  Â  Â  Â  discussion with you:

Â  Â  Â  Â  Â  The "Calibrating the data" section: we
Â  Â  Â  would like it to be
Â  Â  Â  as much
Â  Â  Â  Â  Â  as possible clear and simple. We think
Â  Â  Â  that the matricial
Â  Â  Â  notation
Â  Â  Â  Â  Â  which George used in its presentation at
Â  Â  Â  the tutorial last
Â  Â  Â  year
Â  Â  Â  Â  Â
Â  Â  Â  (http://www.alma.inaf.it/__images/MoellenbrockBologna1.__pdf
Â  Â  Â  [5]
Â  Â  Â  Â  Â
Â  Â  Â  <http://www.alma.inaf.it/images/MoellenbrockBologna1.pdf
Â  Â  Â  [6]>)
Â  Â  Â  Â  Â  would be good, and we started writing it
Â  Â  Â  but still more work
Â  Â  Â  is
Â  Â  Â  Â  Â  needed to make it clear.

Â  Â  Â  Â  Â  We followed Hiroshi's script, but we
Â  Â  Â  ordered the tasks
Â  Â  Â  differently
Â  Â  Â  Â  Â  to clearly separate the polarization
Â  Â  Â  calibration part from
Â  Â  Â  the
Â  Â  Â  Â  Â  "normal" parallel-hands calibration
Â  Â  Â  (bandpass and gain).
Â  Â  Â  Â  Â  The important thing we need to clarify
Â  Â  Â  better is the
Â  Â  Â  parang=T or F.
Â  Â  Â  Â  Â  You can see in the casaguides is one of
Â  Â  Â  the points where
Â  Â  Â  more often
Â  Â  Â  Â  Â  notes are added and help is needed!

Â  Â  Â  Â  Â  While we keep adding plots, and the June
Â  Â  Â  dataset
Â  Â  Â  polarization part,
Â  Â  Â  Â  Â  could you please look at the description
Â  Â  Â  we wrote so far and
Â  Â  Â  in
Â  Â  Â  Â  Â  particular at the most critical points?

Â  Â  Â  Â  Â  If you will have time for a telecon in the
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Â  Â  Â  next days, this
Â  Â  Â  would be
Â  Â  Â  Â  Â  very helpful for us.

Â  Â  Â  Â  Â  Thank you very much,
Â  Â  Â  Â  Â  Arturo, Nuria and Rosita

Â  Â  Â  --
Â  Â  Â  
************************************************************************
Â  Â  Â  *Dr. Catherine Vlahakis*
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Â  Â  Â  <mailto:cvlahaki@alma.cl>
Â  Â  Â  
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Â  Â  Â  --
Â  Â  Â  Hiroshi NAGAI < hiroshi.nagai@nao.ac.jp >
Â  Â  Â  NAOJ Chile Observatory (ALMA)
Â  Â  Â  TEL: +81-422-34-3900 [9] (#3128)
Â  Â  Â  FAX: +81-422-34-3764 [10]

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Â  Â  Â  [3]
http://www.alma.inaf.it/index.__php/3C286_Band6Pol___Calibration_for_CASA_4

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http://www.alma.inaf.it/index.php/3C286_Band6Pol_Calibration_for_CASA_4.2
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Â  Â  Â  http://www.alma.inaf.it/images/MoellenbrockBologna1.pdf
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Â Â Â [10] tel:%2B81-422-34-3764

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