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Geoscientific Instrumentation Methods and Data Systems Discussions
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Interactive comment on "Auroral meridian scanning photometer calibration using Jupiter" *by* Brian J. Jackel et al.

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We sincerely appreciate the detailed comments by the reviewers which have resulted in substantial improvements to the manuscript. Specific responses to each point are included below.

Reviewer#2 ======================= This manuscript concerns using observations of Jupiter for calibrating groundbased meridian scanning photometers (MSP). Using stars for geometrical calibrations of auroral imagers is well-established since a couple of decades. Using stellar spectras for absolute calibration is not as common. Relating such calibrations to laboratory calibrations with LBS is not frequently done. The task of calibrating auroral instruments is extremely important and the authors suggest considerable improvements to existing practices. This paper should therefore be accepted after a minor revision. ========================

Detailed minor comments and suggestions:

"1. Introduction": Well written and easy to follow but it could be improved by referring to earlier work in the field. This is done on page 29, maybe consider moving this part here? Using stars for geometrical calibration dates back to (at least) the 1970s, several attempts has also been made over the years to use stars for absolute calibration. (Generally speaking this paper is well-referenced apart from the introduction).

—Yes. The paragraph with key references has been moved from the discussion to the introduction.

page 3 line 17: "several extremely bright lines and bands from atomic oxygen and molecular nitrogen" "extremely bright" is maybe exaggerating a bit. Relatively speaking it is correct, but not even the brightest line of atomic oxygen is "extremely bright", not to mention first negative at 427.8 nm Please consider rephrasing this.

—Good point. New text: " Auroral spectra are dominated by several relatively bright lines and bands from atomic oxygen and molecular nitrogen, with many other less intense features ranging from extreme ultra-violet through to far infra-red. "

Page 5, line 4: What does "luminosity" stand for here? Please clarify. Total energy emitted by the object?

—"Spectral radiance" was intended, but now we simply say "distribution of incident light".

page 5-6 1.2.1 Geometric: Please add suitable references to this section.

—Added references to seminal work by Stormer, Chapman etc. on page 3.

page 7, line 9 "Photometry" Please consider using "Radiometry" instead. Photometry is easily confused with photometric units, which are irrelevant here.

—Good point. Several other instances of "photometry" and "photometric" have also been replaced with radiometry and radiometric.

page 7 Eq(8): Something is wrong here. Radiance has units watts per (squaremeter steradian). Either sr is missing or the authors intended something else. The symbol L is commonly used for radiance. Please correct or clarify. See also below. How is radiance of a point-source defined?

—Yes, it should have been "irradiance". We have reviewed all other instances of "radiance" and "irradiance" and believe that they are used appropriately.

Page 7, equation (10) The column emission rate is 4L =R 10 : : : (see Hunten 1956)

—Yes, fixed.

page 7, line 19: "has units of radiance" is the apparent radiance. (See Baker& Romick 1976) This section (1.2.3) could maybe be clarified by starting with the basic quantity radiance (L) of an extended source (aurora), then discuss the Rayleigh and proceed to irradiance (E) at the detector. Then treat the case of a point source and 1=r2.

—When writing the paper we tried both approaches, and decided that starting with a point source was better suited for this case. Could the reviewer suggest a reference to the other approach?

Page8, lines 18ÂŰ19: "Only the brightest stars can produce count rates comparable to background contributions such as airglow. " Incorrect! Typically hundreds of stars per image are normally used for geometrical calibration of images from imagers equipped with narrow-band interference filters.

—Yes, under very good viewing conditions a modern narrow-band ASI can resolve many hundreds of stars. However, for red-line observations at 630nm with a 3nm passband, a few hundred Rayleighs of airglow can make it much more difficult to resolve more than a few dozen of the brightest stars. New text: "" Most astronomical objects are effectively point sources, and under good viewing conditions modern all-sky imagers can resolve hundreds of stars with a relatively short exposure time. Ironically, the presence of bright aurora or airglow can be a major source of error in radiometric calibration. For the MSP considered here, the total light from Vega passing through through a 3 nm filter is approximately 200 Rayleighs, which is comparable to typical red-line airglow emissions. Even on a moonless night, continuum emissions can be on the order of 10 R/nm, equivalent to stars of magnitude 2 as observed by our MSP. Note that there are only 50 stars of magnitude 2 or brighter, and fewer than half of them are visible from the northern auroral zone at any given time. ""

Page 9 table 2: [sm2 nm]??1 is centered above [J] and [#] looks strange.

—True. Moved units into table caption.

page 10 lines 14ÂŰ15: "...is still a hundred times brighter than the brightest aurora." IBC-IV aurora (1 MR at 557.7 nm) is often compared to the luminous intensity of the full moon (0.1 Lux for a human observer) . This doesnÂŠt make sense with "a hundred times brighter"

—Good point. We mistakenly used 100kR as an upper limit for auroral brightness. New text: " Despite this substantial decrease, the equivalent lunar brightness of nearly 10 megaRayleighs per nanometer (Table 2) is still 10 times greater than the brightest aurora (1 megaRayleigh for IBC-IV). " After some cross-checking of Table 2 (below), I'm reasonably confident that the energy and number flux values are correct.

1) The solar energy flux at 556 is 1.81 J/s/mˆ2/nm from Table 2, which is consistent with Figure 3. 2) The ratio of moon to sunlight from Table 2 is about 391000, which is consistent with the widely quoted astronomical difference in magnitudes of 14 (2.51ˆ14 $\sim$ 398000). 3) Assuming the energy of a green photon to be 4e-19 Joules gives the same number flux as Table 2.

If so, then neglecting atmospheric absorption the full moon differential irradiance will be roughly 1300 x 1e10 photons/mˆ2/second/nm at 556nm. If those photons were isotropically distributed then the radiance would be L = 100 x 1e10 photons/mˆ2/second/nm per steradian or 1300 Rayleighs per nanometer.

For an MSP with 0.002 steradian FOV the result is roughly 8 MR/nm. If the moon completely fills the field of (6.67e-5 steradians) then then equivalent brightness is 250 MR/nm.

Looking at Chaimberlain Appendix II the IBC-IV is defined just in terms of 1e6 Rayleighs. Later sources (eg. Hargreaves) add qualitative descriptions such as "Full Moonlight". However, it is not clear what FOV or bandwidth are intended. Without this information it is difficult to make a quantitative comparision. Further comments regarding this (or any other point) would be appreciated.

page 17 Eq. (30): No reason to use the inverse of Eq(29).

—Agreed.

page 28, Eq(34): This equation is central to the paper and should be discussed in greater detail.

—Most of the next page is spent discussing the terms which contribute to this equation. Is more detail required? Is something missing?

page 29 line 12 ÂŰ page 31 line 7: Please consider moving (parts of) this text to the introduction.

—Yes. Paragraph with key references is now in the introduction where it belongs.

page 32 lines 6ÂŰ8 "An arc moving from the horizon to zenith will become brighter, not because of any change in precipitation, but simply due to reduction in total airmass between auroral altitudes and a ground-based observer." Correct, but please also consider number of photons integrated when looking along the magnetic field-line instead of across it. This is the main cause of the intensification.

—Agreed. New text: " A constant emission feature moving from the horizon to zenith will appear brighter even after accounting for viewing geometry (i.e. Van Rhijn correction) simply due to the reduction in total airmass between auroral altitudes and a ground-based observer. "

page 33 conclusions: Maybe summarize a bit better, and/or include a small table of the most important results. Future outlook?

—Yes, conclusions expanded and (hopefully) improved.

Table 8: clarify units.

—Done.

Figure 1: reproduces badly and lacks site mnemonics (RANK, GILL, etc.)

—Figure re-done.

Figure 2: Keogram empty in printout. Looks good in PDF.

—Figure re-done.

Figure 8. x and y labels in the figure could be improved

—Done.

Please also note the supplement to this comment:
http://www.geosci-instrum-method-data-syst-discuss.net/gi-2016-5/gi-2016-5-AC2-supplement.pdf

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