



Astronet FP7 community forum

Discussion around Science Vision and Infrastructure roadmap

[Skip to content](#)

[Advanced search](#)

- [Board index](#) < [Science Vision](#) < [Panel C](#)
- [Change font size](#)
- [E-mail friend](#)
- [Print view](#)

- [User Control Panel \(0 new messages\)](#) • [View your posts](#)

- [FAQ](#)
- [Members](#)
- [Logout \[pjvgarcia \]](#)

[Importance of IR interferometry for star/planet formation](#)

[Post a reply](#)

1 post • Page 1 of 1

- [Report this post](#)
- [Reply with quote](#)

[Importance of IR interferometry for star/planet formation](#)

by [skraus](#) » Sun Nov 03, 2013 10:05 pm

Dear colleagues,

on behalf of my colleagues from the European Interferometry Initiative (EII), I would like to thank the ASTRONET panel members for their efforts & dedicated work in providing a roadmap for the future of European astronomy.

In this post, we would like to highlight the importance of optical high angular resolution observations for answering some of the fundamental questions that are addressed in the ASTRONET SV document. The existing monolithic optical telescopes are limited to diameters of about 10m, which corresponds to a

diffraction-limited resolution of about 0.04" at near-infrared wavelengths of 2 micrometer, or physical scales of about 6 AU at the distance of Taurus. This limitation is even more severe at mid-infrared wavelengths (e.g. 10 micron), which are particularly important, for instance, to study the early stages of planet formation. The planned generation of extremely large telescopes will provide only a marginal improvement in this respect, namely by a factor of 3 to 4.

Long-baseline interferometry thus remains the only option to reach spatial information at substantially higher (sub-)milliarcsecond resolution. Having access to these small spatial scales at visual and infrared wavelengths is indispensable to understand the fundamental physics of stars at all evolutionary stages and to image the atmospheric features, dynamics, and activity in stars other than the sun. High angular resolution is essential to advance our understanding of the mass accretion and ejection processes that occur during the star formation process, to study the formation and evolution of multiple systems, or to detect planetary-mass objects in their accretion phase. Only the combination of all technically feasible spatial scales and wavelengths will allow astronomers to reveal the nature of complex, multi-dimensional processes like planet formation.

A major achievement of European astronomy during the last decade has been the construction and early scientific exploitation of the Very Large Telescope Interferometer (VLTI), which has incorporated resources from ESO, the EU, and from the national funding agencies of various member states. In our view, the current scientific output and future potential of visual+infrared interferometers are not sufficiently represented in the ASTRONET SV document, in particular in the light of the upcoming 2nd-generation VLTI instruments GRAVITY and MATISSE.

Therefore, we have prepared the attached document, where we highlight some specific paragraphs of the ASTRONET SV and SV update document and propose possible amendments. My colleagues from the EII science council and myself are looking forward to discuss these ideas with the panel members and the community at large.

Best regards,
Stefan Kraus (President of the EII science council),
on behalf of the EII-SC (<http://www.european-interferometry.eu>)

Dr. Stefan Kraus,
Rutherford Fellow & Proleptic Lecturer
University of Exeter, Astrophysics Group
Stocker Road, Exeter, EX4 4QL, UK
Phone +44-1392-724125
email: skraus@astro.ex.ac.uk
<http://www.european-interferometry.eu>

Attachments

- [ASTRONET_SV_feedback.pdf](#)
EII feedback on SV document
(149.21 KiB) Not downloaded yet

[skraus](#)

Posts: 2

Joined: Tue Oct 15, 2013 11:52 am

- [Private message](#)

[Top](#)

[Post a reply](#)

1 post • Page 1 of 1

[Return to Panel C](#)

Jump to: <input type="text" value="Panel C"/> <input type="button" value="Go"/>

[Who is online](#)

Users browsing this forum: [pjvgarcia](#) and 0 guests

- [Board index](#)
- [Subscribe topic](#)
- [Bookmark topic](#)
- [The team](#) • [Delete all board cookies](#) • All times are UTC

Powered by [phpBB](#)® Forum Software © phpBB Group



Astronet FP7 community forum

Discussion around Science Vision and Infrastructure roadmap

[Skip to content](#)

<input type="text" value="Search..."/>	<input type="button" value="Search"/>
Advanced search	

- [Board index](#) < [Science Vision](#) < [Panel A](#)
- [Change font size](#)
- [E-mail friend](#)
- [Print view](#)

- [User Control Panel \(0 new messages\)](#) • [View your posts](#)

- [FAQ](#)
- [Members](#)
- [Logout \[pjpgarcia \]](#)

[Importance of IR interferometry for strong gravity studies](#)

[Post a reply](#)

<input type="text" value="Search this topic..."/>	<input type="button" value="Search"/>
---	---------------------------------------

1 post • Page 1 of 1

- [Report this post](#)
- [Reply with quote](#)

[Importance of IR interferometry for strong gravity studies](#)

by [skraus](#) » Sun Nov 03, 2013 10:02 pm

Dear colleagues,

on behalf of my colleagues from the European Interferometry Initiative (EII), I would like to thank the ASTRONET panel members for their efforts & dedicated work in providing a roadmap for the future of European astronomy.

In this post, we would like to highlight the importance of optical high angular resolution observations for answering some of the fundamental questions that are addressed in the ASTRONET SV document. The existing monolithic optical telescopes are limited to diameters of about 10m, which corresponds to a

diffraction-limited resolution of about 0.04" at near-infrared wavelengths of 2 micrometer, or physical scales of about 2 lightdays at the distance of the Galactic Centre. The planned generation of extremely large telescopes will provide only a marginal improvement in this respect, namely by a factor of 3 to 4.

Long-baseline interferometry thus remains the only option to reach spatial information at substantially higher (sub-)milliarcsecond resolution. Having access to these small spatial scales at visual and infrared wavelengths is indispensable to understand the fundamental physics of accretion onto compact objects and to probe the regime of strong gravity. High angular resolution is needed to spatially resolve pre-supernova progenitors and to constrain the astrophysical parameters of presumable gravitational wave emitters (e.g. binary black holes, neutron stars). Only the combination of all technically feasible spatial scales and wavelengths will allow astronomers to reveal the nature of complex, multi-dimensional processes like the evolution of black holes.

A major achievement of European astronomy during the last decade has been the construction and early scientific exploitation of the Very Large Telescope Interferometer (VLTI), which has incorporated resources from ESO, the EU, and from the national funding agencies of various member states. In our view, the current scientific output and future potential of visual+infrared interferometers are not sufficiently represented in the ASTRONET SV document, in particular in the light of the upcoming 2nd-generation VLTI instruments GRAVITY and MATISSE.

Therefore, we have prepared the attached document, where we highlight some specific paragraphs of the ASTRONET SV and SV update document and propose possible amendments. My colleagues from the EII science council and myself are looking forward to discuss these ideas with the panel members and the community at large.

Best regards,
Stefan Kraus (President of the EII science council),
on behalf of the EII-SC (<http://www.european-interferometry.eu>)

Dr. Stefan Kraus,
Rutherford Fellow & Proleptic Lecturer
University of Exeter, Astrophysics Group
Stocker Road, Exeter, EX4 4QL, UK
Phone +44-1392-724125
email: skraus@astro.ex.ac.uk
<http://www.european-interferometry.eu>

Attachments

- [ASTRONET_SV_feedback.pdf](#)
EII feedback on SV document
(149.21 KiB) Downloaded 1 time

[skraus](#)

Posts: 2

Joined: Tue Oct 15, 2013 11:52 am

- [Private message](#)

[Top](#)

[Post a reply](#)

1 post • Page 1 of 1

[Return to Panel A](#)

Jump to: <input type="text" value="Panel A"/> <input type="button" value="Go"/>

[Who is online](#)

Users browsing this forum: [pjvgarcia](#) and 0 guests

- [Board index](#)
- [Subscribe topic](#)
- [Bookmark topic](#)
- [The team](#) • [Delete all board cookies](#) • All times are UTC

Powered by [phpBB](#)® Forum Software © phpBB Group

Feedback from the Science Council of the European Interferometry Initiative (EII) on the Update of the ASTRONET Science Vision Document

This document refers to the “ASTRONET Science Vision Update” document (Version from 4th of June 2013; http://www.astronet-eu.org/IMG/pdf/ASTRONET_SV_update_2_0-2.pdf) and the original SV document.

With contributions from members and associates of the European Interferometry Initiative (EII) Science Council, in particular Olivier Chesneau, Sebastian Hönig, Stefan Kraus, Jörg-Uwe Pott, and Jean Surdej.

The construction and scientific exploitation of the Very Large Telescope Interferometer (VLTI) is a major achievement of the European astronomical community and incorporates resources from ESO, the EU, and from the national funding agencies of various member states.

In our view, the current scientific output and future potential of visual+infrared interferometers are not sufficiently represented in the ASTRONET SV document, in particular in the light of the upcoming 2nd-generation VLTI instruments GRAVITY and MATISSE.

While monolithic telescopes are currently limited to about 10m diameter, long-baseline interferometry remains the only option to reach spatial information at substantially higher, milliarcsecond resolution. Having access to these small spatial scales at optical and infrared wavelengths is indispensable to understand the fundamental physics of stars and accretion onto compact objects as well as spatially resolving the regime of strong gravity. High angular resolution is needed to study the fundamental properties of stars and the astrophysical parameters of presumable gravitational wave emitters (e.g. binary black holes, neutron stars). Only the combination of all technically feasible spatial scales and wavelengths will allow astronomers to reveal the nature of complex, multi-dimensional processes like planet formation and the evolution of black holes.

On the following page, we cite specific paragraphs of the ASTRONET SV Update document (gray shaded), propose possible amendments (printed in bold red font), and outline our thoughts behind these suggestions.

Chapter “Executive Summary”:

Page 4: A key question for the future is how much this view can also fit the high-mass star formation regime. It is clear that dynamical interactions in clusters have to play a significant role and exploring these systems at the same linear resolution (or better) as the nearby (low-mass) regions is a high requirement.

VLTI interferometry has allowed resolving AU-scale discs around high-mass protostars (e.g. Kraus et al. 2010, Nature, 446, 339) and provides detailed information about the multiplicity of these sources. More than 24 massive YSOs have now been studied with this technique (e.g. Boley et al. 2013, astro-ph/1308.4282), which demonstrates that this approach is applicable for a meaningful sample of objects. Therefore, we propose to add the following sentence at the end of this paragraph:

This requires high resolution observations at near-/mid-infrared and (sub-)millimetre wavelengths, together with dynamical studies of resolved stellar populations, e.g. VLTI and ALMA.

Chapter “ASTRONET: Science Vision Update: the details”:

Chapter 1.2 (page 10) of the original SV document contains the following sentence: While infrared-optical interferometry is presently a highly challenging and somewhat experimental technique, further progress in single-mode optical fibers, integrated optics, lasers and fast control systems is expected to make (sub) milli-arcsecond imaging interferometry widely applicable in the next ten years.

We propose to change the narrative of this paragraph as follows:

The VLTI with its first-generation instruments, MIDI, AMBER, and PIONIER has shown that optical-infrared interferometers can be operated routinely in an efficient manner and that this technique is now applicable to address a wide range of questions in stellar and extragalactic astronomy. The upcoming 2nd-generation instrumentation projects and infrastructure improvements are expected to increase the sensitivity and imaging capabilities of VLTI, which should also contribute to growing the user base of VLTI.

There is little doubt that following the erection of ELTs with diameters up to 39m, there will be a real need to complement the high angular resolution parameter space with optical, near- and mid- IR kilometric long baseline interferometers. Different concepts are presently under active and concerted studies in Europe and in the USA. On a shorter timescale, technological improvements of the existing VLTI infrastructure might also be foreseen to fill this gap.

Page 7: The changes are listed below and current facilities/missions now operating/launched since the Science Vision publication include:

...

Current major instrumentation now includes:

X-Shooter (VLT); KMOS (VLT); **AMBER (VLTI); PIONIER (VLTI); VEGA (CHARA); SCUBA-2 (JCMT)**

We recommend including in this list the EU-lead interferometry instrumentation projects that have started operation since 2007, namely AMBER, PIONIER, and VEGA.

Chapter “Panel A: Do we understand the extremes of the universe?”:

Page 9: 2.3: Can we observe strong gravity in action?

In section 2.3.2 on p28, good progress with VLBI has been made and new observations using mm VLBI (1.3 mm) of the Galactic Centre have been achieved and these reveal structure on scales comparable to the event horizon (see e.g. Fish et al. 2011, ApJ 727, L36). Furthermore, in regard to Sgr A*, flaring activity is observed in both X-rays, infrared and radio on time- scales of less than hours, thereby probing activity within 10's of Schwarzschild radii.

Studying the general relativistic effects near the Galactic Center is also the major science objective of the GRAVITY instrument that is scheduled for commissioning in 2014. We propose to add at the end of this paragraph:

The VLTI/GRAVITY experiment has been designed to reveal the origin of these flares and to measure the spin and inclination of the Galactic Center black hole.

Page 9: 2.4: How do supernovae and gamma-ray bursts work?

For the description of the core-collapse supernovae on p32, we now know a little more about the fundamental questions and we can add that there is still a dearth of observations of progenitor objects, especially for the high mass end and ask which of these collapse to black holes, which to neutron stars and what is the nature of the recently discovered super-luminous supernovae.

We suggest mentioning the progress that could be made in this field by studying the properties of pre-supernova progenitor systems:

Advancements in our understanding of the explosion mechanisms can also be expected by studying pre-supernovae progenitor systems with VLTI infrared interferometry, for instance (1) to establish the angular momentum transfer of closely interacting massive binaries, or (2) to measure of the radius of pre-supernova progenitors for comparison with theoretical models predicting the light curve and other supernova properties.

Page 10: 2.5: How do black hole accretion, jets and outflows operate?

During the last years, there has been considerable progress in exploring the parsec-scale circumnuclear environment of AGNs using near- and mid-infrared interferometry. These observations provide support for a connection between the mass supply from the black-hole surroundings and the accretion state of the black hole, and revealed inhomogeneities in the circumnuclear material, commonly referred to as "clumpiness" (Jaffe et al. 2004, Tristram et al. 2007, Schartmann et al. 2005, Hönig et al. 2006). Also, dusty winds have been identified as a major contributors to the infrared emission (Hönig et al. 2012, 2013, Tristram et al. 2012) and it has been found that mid-IR emission, as opposed to the near-IR, has a strong or even dominating component associated with the region/direction of gaseous outflows from the accreting supermassive black hole.

We propose mentioning some of these novel findings, for instance with the following paragraph:

The continuous improvement of sensitivity of infrared long baseline

interferometry over the last years allows now to study statistically relevant samples of AGN dust tori (e.g. Burtscher et al. 2013), thus spatially resolving the reservoir of feeding material in direct interaction with the central black hole. These observations have provided direct evidence for a luminosity/accretion rate-dependence of the mass distribution on pc scales (Kishimoto et al. 2011, A&A 536, 78; Burtscher et al. 2013, astro-ph/1307.2068), providing strong support for a connection between the mass supply from the black-hole surroundings and the accretion state of the black hole, although significantly more observational and theoretical work has to be done to understand its origin. The accretion structures on the VLTI-resolved scales show strong signs of a high density contrast, commonly referred to as "clumpiness". The nature of the high-density regions is not understood, and can range from remnants of accreted molecular clouds, star-forming regions, or filaments produced by stellar outflows in the inner galaxy.

Chapter 2.5.2 (Page 37) of the original SV document contains the following sentence:

For most objects the horizon itself will remain outside our reach (except for sub millimetre **and near-infrared interferometry** of the Galactic Centre **and M87**).

Probing spatial scales comparable to the event horizon of the Galactic Centre is the main science objective of the VLTI/GRAVITY instrument, which is scheduled for first light in 2014. Therefore, we propose mentioning these prospects.

Also, for the elliptical galaxy M87 the linear scale of the event horizon is expected to be comparable to the one for the Galactic Centre (<http://eventhorizontelescope.org/science/index.html>), so that both of these SMBH could be mentioned in this context.

Chapter 6.2 (Page 133) of the original SV document contains the following sentence:

Very long-baseline (4000 km) interferometry at sub-millimetre wavelengths will be essential for goal 5. In combination with the large collecting area of ALMA, this technique offers the combination of resolution and dust-piercing wavelength to image near to event-horizon accretion flows within the Milky Way.

We propose to mention the applicability of near-infrared interferometry for studying the event horizon in the Galactic Centre:

Interferometry at near-infrared or sub-millimetre wavelengths will be essential for goal 5. In combination with the large collecting area of ALMA, sub-millimeter very long-baseline (4000 km) interferometry could offer the combination of resolution and dust-piercing wavelength to image near to event-horizon accretion flows within the Milky Way; A near-infrared interferometric facility with kilometric baselines could extend this science case also to the most nearby black holes in nearby active galactic nuclei.

Chapter “Panel C: What is the origin and evolution of stars and planets?”:

Page 15: 4.1: A key question for the future is how much this view can also fit the high-mass star formation regime. It is clear that dynamical interactions in clusters have to play a significant role and exploring these systems at the same linear resolution (or better) as the nearby (low-mass) regions is a high requirement. (as in “Executive summary” listed above)

VLTI interferometry has allowed resolving AU-scale discs around high-mass protostars (e.g. Kraus et al. 2010, Nature, 446, 339) and provides detailed information about the multiplicity of these sources. More than 24 massive YSOs have now been studied with this technique (e.g. Boley et al. 2013, astro-ph/1308.4282), which demonstrates that this approach is applicable for a meaningful sample of objects. Therefore, we recommend adding the following sentence at the end of this paragraph:

This requires high resolution observations at near-/mid-infrared and (sub-)millimetre wavelengths, together with dynamical studies of resolved stellar populations, e.g. VLTI and ALMA.

Chapter 4.1.3 (Page 75) of the original SV document contains the following sentence:

On the observational side, the distribution of stellar masses, binary fractions and other key properties of dense young stellar clusters will require a significant advance in optical and infrared telescopes. To appropriately investigate the cores of the most dense and massive young stellar clusters of our own Galaxy will require an ELT with adaptive optics. To explore the properties ‘at birth’, before dynamical evolution, even younger clusters will need to be explored at high angular resolution in the infrared and (sub-)millimetre with **VLTI**, JWST, and ALMA.

With a 5-10 times higher spatial resolution than JWST and ALMA, optical interferometry is highly effective to resolve close multiple systems and to trace the orbital motion of these systems, providing access to fundamental parameters like dynamical masses and parallaxes. This technique is also applicable for deeply embedded objects, for instance at mid-infrared wavelengths with VLTI/MIDI and VLTI/MATISSE. Therefore, we propose to add “VLTI” to the list above.

Chapter 4.2.3 (Page 81) of the original SV document discusses the science prospects of GAIA:

Gaia will provide a very accurate position of the zero-age main sequence in the HR diagram, thereby contributing to the improvement of the determination of the helium content; it will provide membership, extremely accurate distance (to one per cent) and photometry of most galactic open clusters, providing a dramatic improvement in quantifying all effects of metallicity and helium content; it will provide membership, distance and photometry of all globular clusters within 10 kpc, thereby giving an excellent definition of the turn-off regions which are clues to age determination. **Combining GAIA distance measurements with the direct radii measurements provided by optical interferometry results in particularly strong constraint for the evolutionary modeling of stars of all spectral types.** The simultaneous availability of seismological measurements and absolute magnitudes will also allow separating the effects of rotation and overshooting on the position of a star in the HR diagram. **When interferometry is used in conjunction with astroseismology, the age of the star is inferred with accuracy, with a deep impact on population synthesis and galactic archaeology. It is worth noting that the angular diameter**

and parallax are two key quantities independent of reddening, hence less biased than spectrophotometric methods (Cunha et al. 2007, A&ARv 14, 217).

We propose highlighting the complementary nature of GAIA distance measurements and direct radii measurements for constraining stellar evolutionary models.

Page 17: 4.4: How do planetary systems form and evolve?

Direct imaging of disks with extreme adaptive optics at large optical/infrared telescopes (VLTI) is also producing essential constraints that are complementary to the millimetre observations.

There might be a typo, as extreme adaptive optics systems like SPHERE will be installed on VLT, instead of VLTI. Also, it should be noted that these systems will not be optimized for imaging the diffuse emission around pre-main-sequence discs, as required for the corresponding science objective. Therefore, we recommend to rephrasing this paragraph in an infrared interferometry context and to emphasize the complementary nature of such observations with respect to ALMA:

Essential constraints on the dust distribution in protoplanetary discs are also provided by near- and mid-infrared long-baseline interferometry, which probes a highly complementary regime of stellocentric radii, dust temperatures, grain sizes, and dust opacities compared to millimetre interferometry.

Chapter 4.4.3 (Page 90) of the original SV document discusses the prospects for observing structures in protoplanetary discs at high angular resolution:

Observations of structures in discs (spirals, gaps, density enhancements) and the newly formed planets within discs are all powerful tools that require the next generation facilities that will offer high angular resolution and sensitivity (ALMA, **VLTI**, **CHARA**, JWST, ELT, SKA, and a far-infrared interferometer in space).

The sensitivity limits of the existing VLTI instrument (e.g. H=10 with PIONIER and the UTs, H=7.5 with PIONIER and the ATs, N=0.05 Jy with MIDI and the UTs) permit now observations on a significant sample of protoplanetary disc, including a few hundred Herbig and T Tauri stars and dozens of transitional discs. Such observations provide an effective probe of small-scale disc structures, such as disc gaps or density asymmetries (e.g. Olofsson et al. 2013, A&A 552, 4). Upcoming instruments and facility upgrades will also further enhance the imaging capabilities, which will simplify the interpretation of optical interferometric data. Therefore, we recommend adding optical interferometers to the list in this paragraph.

Page 17: 4.5: What is the diversity of planetary systems in the Galaxy?

Direct detection techniques have also started to contribute significantly in recent years and the arrival of SPHERE at the VLT will certainly be a major milestone in the short-term.

Over the last few years, aperture masking interferometry has proven to be an efficient technique for detecting young protoplanets that is also applicable to fainter objects than those that can be observed with extreme adaptive optic systems.

We suggest the add the following sentence:

Aperture masking interferometry at infrared wavelengths has proven to be an efficient technique for detecting young protoplanets (e.g. Kraus & Ireland, 2012 ApJ 745, 5) and further detections can be expected from the imaging-optimized near- and mid-interferometric instruments at VLTI and from the ELTs.

Chapter 6.4 (Page 137) lists the current facilities and the need for upgrades in order to meet the future science requirements

The current list makes no recommendations for future developments of existing optical interferometric facilities such as the VLTI, even though it is clear that milliarcsecond-resolution imaging capabilities will be highly relevant for addressing some of the key science questions in this section.

Ground-based near- and mid-infrared interferometers such as the VLTI offer access to the milliarcsecond-resolution imaging regime, which is essential for goals 2, 3 and 4, and complementary for goal 1. Instrumentation and infrastructure upgrades will allow to exploit the full potential of the existing facilities, increasing both their sensitivity and imaging efficiency.