Role of the National Science Foundation ATM/GEO Directorate in promoting and supporting Space Physics

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1. Introduction

The NSF ATM/GEO Directorate has played a fundamental role historically in supporting space physics. Traditionally, this has taken a broad systems perspective, recognizing that our understanding of geo-spatial processes at 1 Astronomical Unit is informed by physical processes and couplings from regions as diverse as the solar corona and the boundaries of the heliosphere. *Unfortunately, there is an effort within the NSF ATM/GEO Directorate to significantly restrict such a broader perspective by limiting the space physics that is supported to that within 1 AU or which has an obvious demonstrable impact on the Earth.* Such thinking represents both a significant step backwards in our discipline for many reasons, and may in fact not be in compliance with NSF policy. Specifically, the "NSF has long recognized the value of interdisciplinary research in pushing fields forward and accelerating scientific discovery. Important research ideas often transcend the scope of a single discipline or program. NSF also understands that the integration of research and education through interdisciplinary training prepares a workforce that undertakes scientific challenges in innovative ways." [National Science Foundation Investing in America's Future: Strategic Plan FY 2006-2011.] In light of this, the ATM/GEO Directorate appears to be in violation of basic NSF policy by limiting funded research to within 1 AU, and providing no other home for this work.

In this White Paper, we provide just a few examples with which we are particularly familiar to illustrate why such a restriction by the ATM/GEO Directorate is shortsighted.

- With this White Paper, we are requesting that a recommendation be made to the NSF ATM/GEO Directorate that a broad perspective of space physics be adopted and that the Directorate return to compliance with NSF policy. The NSF should support solar and heliospheric physics research within one section and one directorate without imposing an artificial boundary to the heliosphere at 1 AU and without insisting that, to be supported by that directorate, one needs to make the case that the research is of direct relevance to the Earth.
- That the restriction of funding to support studies only within 1 AU or that are directly relevant to the Earth be eliminated;
- And that a panel be established to evaluate the broad compliance of these goals as reflected in funding trends made to individual researchers.

The region within 1 AU is not an environment isolated from the rest of the heliosphere. Several examples point directly to why an understanding of the physics of the interplanetary environment beyond 1 AU has a direct influence on our understanding of geospace, some of which are discussed below. The development of techniques and models and the elucidation of physical processes for regions of the heliosphere beyond 1 AU can frequently shed light on problems within 1 AU. Finally, in attempting to promote the cross-disciplinary and multi-process approach to space physics that is undoubtedly necessary to make the break-through discoveries necessary to advance the field, it is imperative that we not compartmentalize our science. This is especially true if we are to encourage students to enter the field and post-docs and researchers to remain part of the space physics community. This implies that we cannot restrict NSF ATM/GEO supported science to an arbitrary and unphysical 1 AU boundary in the interplanetary medium.

2. Importance of physics beyond the Earth

A major element of space weather is understanding the particle radiation environment at 1 AU, especially solar energetic particles. Much of our current understanding of particle energization derives from diffusive shock acceleration. It hardly needs noting, however, but the entire theory of diffusive shock acceleration was developed without any reference to particle acceleration in the inner heliosphere. Initial papers on the subject focused on particle acceleration at supernova remnants and then later at the heliospheric termination shock. It should be added that this latter application was in fact funded through ATM/GEO many years ago. It was only some 10 years or more later that these ideas migrated into the field of SEPs. Today, such science would not be funded under the current policy because it would not have been immediately obvious how it would have relevance to the Earth. While it is not necessary for ATM/GEO to now consider funding particle acceleration studies at supernova remnants, a better understanding of how particles are accelerated at e.g., the heliospheric termination shock may ultimately shed much light on the general physics of diffusive shock acceleration, and hence on the SEP problem, probably in ways that are difficult to anticipate.

Consider another example which pertains to space weather but which would not be funded under the current policy. The evolution of turbulence in the outer heliosphere, beyond 1 AU, would appear to be of little consequence to our understanding of the transport of solar energetic particles. It has been established that energetic SEPs accelerated within 1 AU and observed at the Earth typically propagate well beyond 1 AU before being scattered back by turbulent magnetic field fluctuations at several 10’s of AU. Turbulence beyond some 5 – 8 AU is very strongly influenced and driven by instabilities associated with the pick up of interstellar neutral hydrogen. Thus, to understand the transport of SEPs and their fluence at 1 AU not only requires ultimately an understanding of turbulence evolution throughout the heliosphere but also a knowledge of the heliospheric structure, properly taking into account the role neutral hydrogen.

A further example, attracting much discussion, is the ubiquity of a v^{-5} spectrum for energetic particles, but this was first discussed in the context of puzzling Voyager observations made in the heliosheath. Besides exploring related observations in the outer heliosphere, theoretical models were developed to describe the observations and these are now finding application in the inner heliosphere. The migration of ideas developed for application to one part of the heliosphere to another part of the heliosphere is almost inevitable and to somehow bound the heliosphere to 1 AU is completely contrary to the way that science is done.

Consider a final example that would certainly not have any possibility of funding under the current policy. Clearly, the historical behavior of the sun and solar wind is of considerable interest to ATM/GEO, especially its potential impact on long-term climate trends. A much cited paper by Wood et al., 2001 presented the Sun's mass loss history, showing how this may be responsible for the loss of the Martian atmosphere, for example. The methodology by which these results were arrived at required sophisticated modeling of nearby stellar astrospheres of G-class stars in partially ionized clouds. The models used were based on simulations developed to understand the interaction of our heliosphere with the local interstellar medium. The heliospheric models predicted the existence of the hydrogen wall, which was subsequently observed using Lyman-alpha absorption measurements. The prediction and subsequent measurement of similar hydrogen walls about the astrospheres of other G-class stars at different stages in their evolutionary history allowed Wood et al. to determine a the history of the Sun's mass loss and related coronal activity. The development of the necessary heliospheric models is not supported under the current funding policy.

A number of additional examples can be provided quite easily from other areas of heliophysics but the point has been made adequately that we should not artificially introduce a boundary of 1 AU in our discipline. It should be evident that understanding the physics of one region of the heliosphere frequently informs our understanding of other aspects and regions. We cannot afford a blinkered approach to the science of heliophysics and we must recognize that the heliosphere is a single, coupled, integrated system. The commonality of physical processes within the heliosphere and the key role of in situ observations, whether by ACE or Voyager, distinguishes the science of heliophysics from astrophysics. We cannot allow the physics of the heliosphere to be shunted off to astrophysics because, for whatever reason, it has been determined that heliophysics ends at 1 AU.

3. Impact on young researchers

A final important point to be made concerns the impact that the current NSF ATM/GEO policy is having on building our field. NSF policy for workforce training suggests the necessity of researchers being trained in all areas of heliospheric research. ATM/GEO policy as implemented will limit the training and career development of the scientists who will be required to conduct heliospheric research in future. The bringing of young researchers into faculty positions in research universities may be the most critical component that will ensure the long-term survival of heliophysics as a discipline. At this point, a young assistant professor whose work investigates for example the structure of the heliosphere would not be able to propose for a CAREER award through the NSF ATM/GEO Directorate (nor indeed for any other form of research support). Unfortunately, heliospheric studies beyond 1 AU without an immediately obvious connection to geo-space cannot be accommodated in the NSF Astronomy section, since astronomers do not regard the Sun as being a particularly special star.

As is typical of many of us in the field of heliophysics, most of us move from one area or region to another within the heliosphere since many of the ideas are interchangeable and offer insight elsewhere. What will happen now is that good young heliospheric scientists will see few opportunities beyond the very narrow compartmentalized options that are currently available and move to different disciplines. Our field will be the ultimate loser, and the research universities will continue to hire in fields that are more promising than heliophysics with a 1 AU boundary.