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HOW MUCH OF THE UNIVERSE IS CONSTANTLY MONITORED BY MODERN ASTRONOMY?

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ABSTRACT

This is the abstract.

Subject headings: stars - supernovae - general

1. 541 FALL 2020 PROJECT - SURVEYING THE TIME-DOMAIN AND QUASI-STEADY UNIVERSE

Astronomy involves a multi-faceted continuous probing of the Universe, near and far. But how continuous and comprehensive in fact is our collective surveying of the sky? It is often assumed by the public that astronomers are aware of all that is occurring, but this is far from the truth. In particular, individual surveys cut in solid angle, wavelength, cadence, and depth (defined in a variety of ways), and some don't involve photons (i.e., gravitational waves, MeV neutrinos, high-energy neutrinos, cosmic rays). So, the question natually arises: what fraction of the multi-dimensional phase space that is the multi-dimensional Universe is actually watched? How aware are we of the Universe at any given time, etc.?

There are now many, and soon will be more, surveys and sentinels of the sky. Time-domain astronomy was a highly-touted theme of the 2010 Decadal Survey and it is assuming an even more central role a decade later. And there are many transients to detect (TDEs, supernovae, novae, flares, GRBs, soft gamma repeaters, X-ray bursts, merging neutron stars and black holes, stellar pulsations, FRBs, transits, breakout bursts, microlensing event, eclipses, LBVs, ...). Most large-scale surveys are tuned to map a distribution of some population, either extragalactic or galactic, but some can also provide rough time stamps. However, many telescopes are "purely" time-domain sentinels for transients that occur within a given phase space. Among surveys and dedicated time-domain telescopes (now and soon to be online) (in no particular order) are: Gaia, WFIRST/Roman, Euclid, DES, DESI, KiDS, eBOSS, Subaru/HSC, Planck, ACT, SPT, eROSITA, Westerbork (WSRT, Apertif), NRAO VLA Sky Survey (VLASS), LOFAR, Owens Valley, eMERLIN, CHIME, ASKAP, MeerKAT, SWIFT/Gehrels, INTEGRAL, NuSTAR, Veritas, MAGIC, VLT Sky Survey (VLASS), VISTA, ZTF/PTF, Starmapper, ASASSN, Catalina/Mt. Lemmon, HAT, NEOWISE, Kepler/K2 (of late), and TESS. Photon wavelengths are in the optical, near-IR, mid-IR, far-IR, radio, UV, X-ray, hard X-ray (NuSTAR), and γ-ray; neutrinos are (or soon will) be caught by SK, HK, DUNE, JUNO, Gran Sasso facilities, IceCube; gravitational waves are being listened for by LIGO/Virgo/Kagra; and cosmic rays are captured at a variety of sites around the world and on the ISS. This list seems large, but is surely incomplete.

Nevertheless, all these facilities have limitations that restrict their coverage in wavelength/energy, cadence, time-of-day, angular sky coverage, depth (in flux, magnitude, distance, volume), angular resolution, and energy resolution, etc. There are also data rate and storage limits, data format challenges, unsaved data, etc. And importantly, the Universe is a big place in "every direction."

The upshot is imperfect awareness of the cosmos. But, how imperfect? How shallow? How wide? How deep? What fraction of the multi-dimensional Universe do we witness? What fraction are we missing? How has this fraction evolved with time? Which are the "best" telescopes for a given wavelength or signature? By when will we be able to monitor the entire Universe in its particulars?

These and other related questions go to the heart of the questions you will address in this seminar. In every "wave band," and for a relevant collection of telescopes, what is the multi-dimensional space surveyed (how deep, what wavelengths, what angular coverage, spectroscopy/photometry?, cadence, North/South?, ground/space, dust obscuration, etc.). The depth issue, when translated into physical distance, is tied to the transient class. An emphasis will be on artful and engaging graphical representations of the search/sentinel space to accompany a discussion of the relevant specifications and coverage. Each student and group will chose (in consultation with me) a wavelength/platform range and determine how much of the galaxy (or Universe) is monitored. The product will be a LaTeX section, with bibtexs and graphics. The graphic(s) should show at a glance how well their telescope/program does at surveying the transient (and surveyed) sky and will be compared to known maps of the galaxy or Universe for reference.

A goal will be to have a 1) uniform format, 2) uniformly excellent graphical rendition, and 3) publication-quality discussion. The various sections will be joined and if the result is appealing and useful the paper with all our names on it will be submitted to an archival journal and (hopefully) published. There (to my knowledge) is no such work in the literature, though this investigation and its conclusions go to the heart of the collective ongoing activity of the world's astronomical enterprise vis à vis time-domain astronomy. Hence, we will ask and answer the question: How much of the sky (in a generalized sense) does international astronomy cover continuously and what would/does the world miss? We will encourage collaboration and discussions among all the students, and expect that best practices (and code/graphics templates) will be shared.

Therefore, the course will focus on assembling descriptions and maps that summarize the current status of

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time-domain transient surveys/sentinels and of surveys (that may not be importantly time-dependent) to address the question of the completeness in area, volume, hemipshere, wavelength, and time, etc. of modern astronomy collectively. Significant emphasis will be placed on impactful graphical representations, and working in collaborative student groups. Sharing best practices will be encouraged, and necessary. During the semester student groups will present their results, obtain feedback from the class, and update their product accordingly. As stated, though not an absolute goal of the course, the contributions in LaTeX and graphics when assembled into a LaTeX compendious document might be submitted to a journal for publication. However, this will be only if a suitable level of consistency, clarity, and "impact factor" is achieved. The author list will be all of us in alphabetical order.

Nothing like this has been attempted across the spectrum of wavelengths and activities, which if done well can be an exciting resource for the astronomical community, and beyond. Even if not published, the exercise will provide a fascinating focus on the collective capabilities of all of astronomy and its current state of awareness of the Universe. The results may be sobering.

2. SECTION 2

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REFERENCES