# A Historical Note on the Harvard College Observatory Announcement Cards: Elizabeth L. Scott at the Intersection of Statistics and Astronomy

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**Abstract**

The Harvard College Observatory Announcement Cards, also known as the Harvard Announcement Cards (HAC), were for 39 years (1926-1964) an important statistical data system used in the western hemisphere for astronomical observations that needed to be reported quickly because they involved objects having transient characteristics. Astronomical announcements of 'current interest' were comets, certain asteroids, new stars, and 'similar matters'. The late statistician Elizabeth L. Scott's first publications were among the 1,674 HAC, including 11 communications over an eight-year period beginning in 1939. The purpose of this historical study is to provide a focused description and review of the HAC as a professional communication system that linked statistics and astronomy in the early 20$^{th}$ century, as evidenced by the participation of Elizabeth L. Scott in the system. This will include describing the function of the HAC and describing and analyzing the reporting content of Scott's HAC. While we could find some brief references to HAC in a few published books and articles, we could find no article in the published literature that focused on them, and likewise no article that described Scott's participation in the system. The HAC were unique for three reasons. First, they provided systematic observational data to astronomers that focused on the transient class of objects rather than the stable class of objects that changed little over time. Second, the HAC system, although primitive by most modern standards in terms of data recording, promoted internationalization of data capture and sharing. Finally, the HAC system highlighted the existence of different classes of astronomical observation and data, as well as the long-term need for more and better record linkage systems in astronomy at the dawn of the electronic computer age.

Key Words: Data system, observational data, international data sharing, record linkage

## 1. Introduction

Noted statistician Elizabeth L. Scott (1917-1988) published early, while she was only age 21 and still an undergraduate student at the University of California at Berkeley in the USA. Scott and fellow astronomy students, undergraduate as well as graduate, had the fortunate opportunity to conduct professional research at the Student's Observatory at Berkeley. This included observing new comets, determining their orbital characteristics, and generating timely associated measurements that were of interest to the wider professional astronomical community and therefore needed to be communicated quickly. The vehicle used in the western hemisphere for such communications between 1926 and 1964 was the Harvard College Observatory Announcement Cards, also known as the Harvard Announcement Cards (HAC).

The importance of the HAC to the field of astronomy was illustrated in the first part of astronomer Dorrit Hoffleit's poem, "Minkowski's 'Nova'" (Hoffleit 2002):

> *Minkowski found a "nova"*
> *On a plate of long ago,*

*So at once he wrote to Harvard*
*To have us check that this was so.*
*Sixth magnitude he'd found the star*
*Near Orion in Gemini.*
*A one so bright in such a place,*
*Where all good amateurs do look,*
*Could hardly have escaped their watch.*
*Yet no Harvard Announcement Card*
*Ever told of its discovery.*
*So something drastic must be wrong!*

The purpose of this historical study is to provide a focused review of the HAC as a professional communication system that linked astronomy and statistics. This will include a description of the features of the HAC as a system, analysis of content of the HAC to discern the types of data reported, and discussion of the impact of the HAC on international data systems. In the area of content, we will focus on the 11 HAC in which Scott was involved.

**2. HAC System Features**

In the world of astronomical observation, discoveries can be split into two classes. The first class includes objects that change little over time and do not require urgent recording and reporting. These objects include pulsars, eclipsing binary systems, dwarf novae, and most asteroids. In the other class, however, are the objects that have transient characteristics. These objects change unpredictably and often suddenly. This second class includes mostly comets, supernovae, planetary cloud and surface features, and near-Earth asteroids.

The HAC were for 39 years an important vehicle for economical reporting of astronomical discoveries that were in the second class, i.e., that needed to be reported quickly because they involved objects having transient characteristics. Prior to the HAC, there was no means in place for astronomers to record the characteristics of transient objects and transmit them quickly and inexpensively to a broad group of interested professionals in the western hemisphere.

The HAC allowed astronomers to send their findings directly to the Harvard Bureau of Astronomical Telegrams to have them archived at the Harvard Observatory and sent quickly from there to subscribers on post cards. The post cards were standard United States Postal Service 3-1/2x5" cards made out of linen paper stock. The front side had a place for an address, and it had preprinted postage. The backside was used for the astronomical announcements.

The HAC were a supplement to the existing Harvard telegraphic service, which was established in the latter half of the 19$^{th}$ century by Edward Pickering, the director for the Harvard Observatory. When individual observatories telegraphed their own astronomical data, the result was often inconsistency, higher costs, more confusion, and greater turn-around-time. The Harvard telegraphic service ameliorated these problems. This service allowed observatories to transmit data regarding an astronomical object to a central hub at Harvard, which would then systematically edit and transmit the data to a larger number of participating observatories (Grier 2013).

Even with a central hub, the telegraph system of communication was expensive. In order to make the communications more widely available, especially to smaller observatories and individuals, the HAC was set up as a system of post card subscriptions that could be used either in conjunction with the telegraph system or as a stand-alone service. Entities that subscribed to the telegraphic service received the HAC without an extra charge. Others who wanted to receive the HAC alone were initially charged only a dollar a year (the first card was issued in 1926) - which would be only about $13.00 today. However, we know that by 1934 subscribers were charged for a fixed number of consecutive cards rather than a yearly subscription fee.

**3. HAC Content**

The first HAC set the standard for what information would be presented on the cards in the future (Shapley 1926). Common ephemeris values such as the spherical coordinates Right Ascension and Declination were presented in order to give astronomers the location of an object within the Celestial Sphere. This first HAC contained ephemeris for Blathwayt's Comet, which specifically included the date in Universal Time (U.T.), Right Ascension (R.A.) in hours, minutes and seconds (h, m, s), Declination (Dec.) in degrees and arcminutes (°, '), the log of the comet's distance from the Earth (log Δ), Brightness (Br.), and relative apparent magnitude (mag.).

A notable collection of HAC pertains to the discovery of Pluto. These were given in card numbers 108 (1930), 112, 113, 117, 118, 119, 121, 129, 131, 133, 134, 136, 137, 148, and 157 (1931). Even though Pluto was *officially* deemed a planet in February of 1930, some of the HAC still referred to it as the "Trans-Neptunian Planet" through April 14 (HAC 121). HAC 121 contains orbital classification elements in addition to the standard ephemeris. This card includes several classification elements which describe the following for Pluto: Time (T), Argument of Perihelion (ω), Longitude of Ascending Node (Ω), Inclination (i), Eccentricity of orbit (e), Semi-major Axis (a) in astronomical units (A.U.), Period of observed orbit (p), and the Perihelion distance (q) in A.U. (IAU Central Bureau for Astronomical Telegrams 2013).

Every HAC, at the bottom, contained the date of publication and the name of the editor. The typical card contained, at the top, the names of the people who computed the ephemeris, where they worked, the dates on which the observations were made, and the professor or other professional who oversaw the observations.

**4. Elizabeth L. Scott's HAC**

There were a total 1,674 cards in the HAC information system. For purposes of content analysis, we have selected the 11 in which Scott was involved. These cards, which were among Scott's first publications, contained measurements on the following comets: Cosik-Peltier, Hassel, Vaisala, Rigollet, Friend, Okabayasi, Okabayasi-Honda, duToit-Neujmin, Schwassmann-Wachmann, and Pajdusakova-Rotbart.

Scott's first HAC, number 471 (Bartlett, Panofsky and Scott 1939a) reported the elements and ephemerides calculations she and fellow students had done on the Cosik-Peltier Comet at the UC-Berkeley Student's Observatory. This was the first comet of 1939 (Crawford 1939).

Scott's work on her third HAC, number 482 (Bartlett, Panofsky and Scott 1939b) was a reexamination of the orbit of the Comet Vaisala. Others had calculated the orbit under the assumption of a ten-year period. Betty and her collaborators had observations over a long arc and were able to recalculate the orbit without assuming a period length. They were then able to conclude that the period was just less than 11 years (Bartlett, Scott, Panofsky 1939).

Each of Scott's HAC included detailed information about a certain comet, although a few general exceptions apply. Often there was information regarding multiple comets on the same card. For example, HAC 540 contained Scott's measurements on Comet Okabayasi as well as another astronomer's measurements of Comet Whipple. Similarly, there were times when information regarding a single comet was present on two or more cards because of the great amount of information regarding that comet. In such a case, the editor would indicate that the details of a certain comet would be presented on the next card. An example of this is (Cunningham and Scott 1946b):

HAC 751: *The ephemeris will appear on II A. C. 752.*

On several of Scott's HAC, the introductory paragraphs state that the information was from more than one source. For example (Bartlett, Panofsky and Scott 1939a):

HAC 471: *Cosik-Peltier Comet. Elements and ephemeris of Cosik-Peltier Comet have been received from three sources: (1) Dr. Paul Herget of Cincinnati, (2) Dr. A. D. Maxwell of Ann Arbor, (3) Mr. T. J. Bartlett, Mr. H. A. A. Panofsky, and Miss E. L. Scott, students in the Berkeley Astronomical Department.*

See also, for example, Scott's HAC 597 & 603 (Scott and Stahr 1941).

In the case of the above example, the editor, Harlow Shapley, would receive the information by various means (telegraph, telegram, air mail, etc.) from each individual source and then compile the findings into one HAC. The compiling process was actually somewhat complicated. The information from each source often differed in amount of detail, as well as the dates on which the comet was observed. This meant that the editor had to assess all of the pertinent information in a way that minimized redundancy and promoted general clarity on the completed HAC.

Aside from the differing amount of detail between individual sources on the same card, the amount of detail often differed greatly across HAC. For example, we may compare HAC 471 (Bartlett, Panofsky and Scott 1939a) and 480 (Kaster, Bartlett, Scott and White 1939). HAC 471 contains the standard computed elements, but also several other notable values. After the elements, HAC 471 contains the dates of the observations and the residuals of those observations. The residuals on this card were the errors in location recording, specifically in minutes of angle. Another item to note is the section of the card referring to Constants of the Equator. The Constants of the Equator are rather complicated values, which are used to find the rectangular coordinates of an object directly from the elements recorded. However, HAC 480 seems almost empty in comparison, only including relatively non-detailed sections of elements and ephemeris.

Scott and her colleagues reported ephemeris with varying degrees of precision depending on the information given to them by the observer(s). HAC 512 (Fel, Scott, White, Irwin and Panofsky 1939) had the most basic ephemeris information: Right Ascension ($\alpha$) described in hours (h) and minutes (m); and Declination ($\delta$) described in degrees ($^o$) and arcminutes ('). HAC 500 (Panofsky and Scott 1939) also included seconds (s) in Right Ascension (R.A.), and HAC 571 (Scott and Panofsky 1941) also included arcseconds (")

in Declination, as well as distance from the sun (r) and distance from the earth (Δ). Other measures related to ephemeris are included depending on the orbital characteristics of the comets. For example, HAC 752 (Cunningham and Scott 1946b) included magnitude (Mag.) computed under various power laws.

Others of Scott's 11 cards include various things to note as well. HAC 540 (Scott 1940) includes "Light", likely an analog to the modern term "surface brightness", as a value along with R.A. and Dec. For all of the cards, the elements were recorded before the ephemeris. On occasion, the astronomers conjectured that one comet might be identical to another. See, for example, Scott's HAC 749 (Cunningham and Scott 1946a), which made such a conjecture, and Scott's HAC 751 and 752, which dismissed the conjecture because the data did not support it (Cunningham and Scott 1946b).

**5. HAC Impact on Global Astronomical Data Systems**

Beginning in the 1880's and overlapping the period in which the HAC system was active (1926-1964) in the western hemisphere, the International Astronomical Union operated a parallel or complementary system, the Central Bureau for Astronomical Telegrams (CBAT), that irregularly also published notices about astronomical discoveries, but in the eastern hemisphere. The hub was originally in Kiel, Germany until World War I broke out. The CBAT was then transferred to Copenhagen, Denmark after a brief stay in Uccle, Belgium (1920-22) and would remain there until 1965. Astronomers, including Scott, often submitted discoveries to both the HAC and CBAT to ensure the widest dissemination.

One point that should be stressed is the impact the HAC system had on the globalization of astronomical information systems. The HAC system was discontinued when on January 1, 1965 the CBAT was moved from Copenhagen Observatory in Denmark to the same building that issued the HAC, namely the Smithsonian Astrophysical Observatory at the Harvard College Observatory in Cambridge, Massachusetts. This move centralized the world's astronomical information recording. Harvard was chosen at least in part because of its success with the HAC system.

Harlow Shapley was the editor for the HAC system for many years as he was the director of the Harvard College Observatory from 1921 to 1952. Shapley was a brilliant astrophysicist, and while he was an outspoken proponent of the incorrect assumption that the entirety of the Universe was contained within the Milky Way galaxy, he was one of the first promoters of the correct idea that the Sun was not the center of the Milky Way. His accomplishments as an astronomer include various books on the sciences; he is additionally credited with helping to found the National Science Foundation, as well as adding the "S" in UNESCO (United Nations Educational, Scientific and Cultural Organization). He also had a deep interest in myrmecology (the study of ants).

**6. Discussion**

The HAC were an important outlet for Scott's early scholarship over an eight-year period, beginning in 1939 in her senior year as an undergraduate student through 1946 as she pursued her graduate studies at Berkeley. In preparing these publications, Scott developed an expertise in measurement that she carried through her entire career as a statistician.

It is a tribute to Scott's research ability and research energy that senior astronomers such as Campbell at Berkeley and C. Donald Shane at Lick Observatory recognized her potential at an early time in her career. By the time Scott published her last HAC, senior statisticians such as Jerzy Neyman at Berkeley were evaluating the young Scott in a similar fashion as she committed to a research career in statistics.

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