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Comet C/1908 R1 (Morehouse) as a C/2016 R2 (PanSTARRS)-like comet

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Introduction

Comets are pristine relics of the early Solar System, formed from the agglomeration of icy grains and dust particles, offering insights into the evolution of the protosolar nebula (PSN). Despite their usual water-ice richness, the blue comet C/2016 R2 (PanSTARRS) exhibited atypical abundance ratios, with an H2O/CO upper limit of less than 0.32% [1], weak CN lines [2], and an exceptionally high N2/CO ratio of 0.09 [3], suggesting unique formation conditions. Our study revisits historical observations of a historical blue comet, C/1908 R1 (Morehouse), utilizing high-precision scanning technology from the New Astrometric Reduction of Old Observations (NAROO) project [4], combined with numerical integration techniques, to reevaluate its dynamical history and spectroscopic data in order to determine the extent of its similarities with C/2016 R2.

Dynamical history

Using two independent dynamical models, MERCURY and REBOUND, we investigated the past trajectory of comet C/1908 R1 by simulating 1000 clones derived from its orbital covariance matrix. Both models revealed that C/1908 R1 has no close encounters with the giant planets, and had likely been stored in the Oort cloud at about 100,000 au, supporting its classification as a dynamically new comet. Despite a hyperbolic orbit with an average eccentricity of 1.16 ± 0.27, the calculated excess velocity v_∞ of 0.83 km/s is much lower than those of known interstellar objects, reinforcing its Solar System origin. We compared this to C/2016 R2's dynamical history [5], but while C/1908 R1 remained dynamically isolated, C/2016 R2 experienced significant gravitational interactions with Jupiter, resulting in a chaotic and unpredictable orbit, though likely an Oort cloud origin.

Spectroscopic analysis

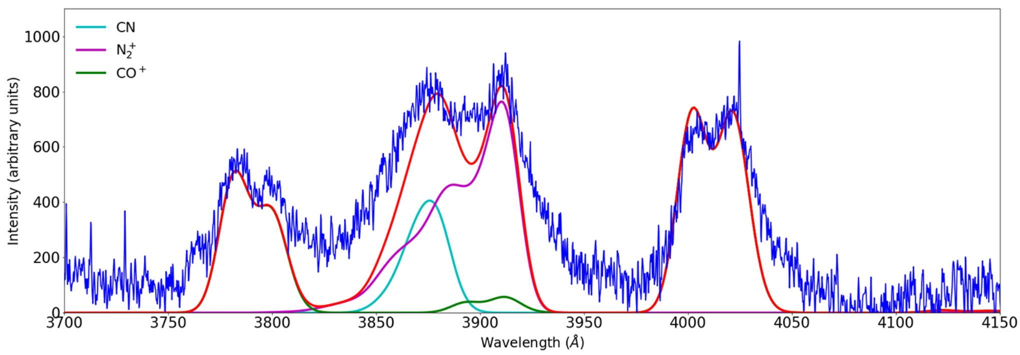
We were able to obtain access to historical photographic plates of Comet C/1908 R1 preserved at the Meudon Observatory, covering observations from October 16 to November 29, 1908, including early spectroscopic data by A. de la Baume Pluvinel [6,7] and A. Bernard [8] from the Juvisy and Meudon observatories, respectively. These were digitized using the NAROO center's high-precision scanner (Fig.1). Despite the historical nature of the data and inherent challenges such as lack of historical information, potential atmospheric extinction misestimation due to lack of standard star identification in some cases, non-linear response of the photographic plates, and optical aberration from the objective prism, we were able to produce high-quality FITS files for detailed analysis and modeling. Spectral extraction involved calibrating wavelength using lines from the comet or reference stars and conducting flux calibration with standard stars such as Vega and Capella. We determined the N2+/CO+ ratios for the combined nights of October 31 and November 1, achieving a fit with a ratio of 7.7%, and on November 28, a slightly lower ratio of 7.2%, indicating consistency in our spectral analysis despite variations in observational conditions and the quality of the plates. Moreover, the analysis confirmed the presence of weak CN bands and subdued dust emissions, traits shared with Comet C/2016 R2, suggesting a low dust-to-gas ratio and a unique evolutionary path for these bodies. These findings, coupled with the identification of previously unrecognized C3 emissions in historical spectra, underscore remarkable compositional similarities between C/1908 R1 and C/2016 R2, hinting at their classification within a rare comet type. However, the question about the exact water ice composition of C/1908 R1 remains open, due to observational limitations of the time.

Tail Morphology

Observations using early photographic methods documented rapid morphological changes in the comet’s tail, exhibiting cycles of brightening, mass ejection, and detachment (TDEs) [9]. We find a recurring interval of approximately 15 days, suggesting influences beyond mere nucleus rotation. These changes correlate with solar activity, as evidenced by concurrent auroral displays, highlighting the tail's sensitivity to solar wind due to its volatile and ionic composition.

Conclusions

Comet C/1908 R1 (Morehouse) presents a compelling study of a dynamically new object, preserved in a pristine state since its origins at the outer edge of the Oort cloud, highlighted by both dynamical models and spectral analysis. Dynamical simulations show no close encounters with giant planets, affirming its status as an untouched relic from the Solar System's early days, while spectral analysis uncovers a unique composition, rich in N2+ and CO+, similar to that observed in Comet C/2016 R2. Despite significant insights, the absence of definitive water ice data leaves its complete classification tentative. With the rarity of blue comets, these findings underscore the importance of integrating historical data with modern scientific techniques.



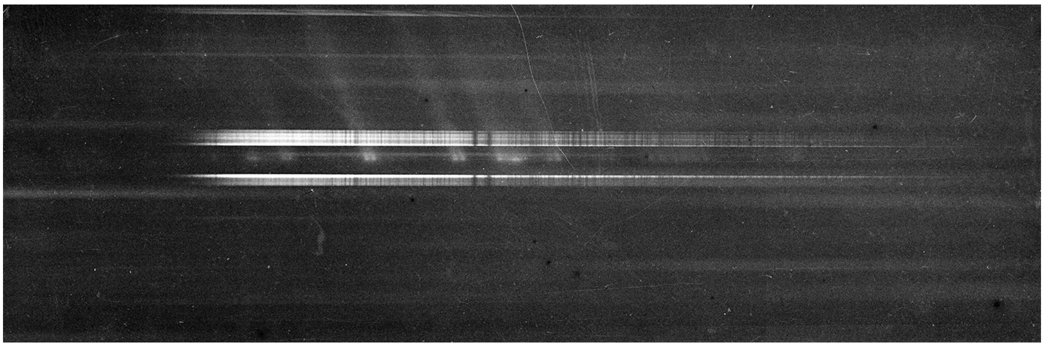


Figure 1: The 1908 spectral plate obtained on October 31 and November 1, 1908, when the comet was 1.07 au from the Sun (left) and the resulting modeling of the extracted spectrum (right), corresponding to the tail region.

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