Observation of a Non-conventional Influence of Earth's Motion on the Velocity of Photons, and Calculation of the Velocity of Our Galaxy

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Abstract— A Michelson-Morley experiment with stationary interferometer operated during 26 months from January 2003 to February 2005 at the International Center for Physics (CIF) in Bogotá, Colombia. This paper reports the final analysis of data. There were large periodical fringe-shifts that were correlated to the environmental variables (temperature, humidity and pressure). After subtracting the fraction of fringe-shift that was stochastically correlated to the environmental variables, we obtained a residual that was no longer correlated to the environment, and represents, therefore, the fringe-shift variation with respect to the motion of earth relative to a preferred frame. The residual also exhibited a 24 h periodicity that was compared to a pre-relativistic model based on Galilean addition of velocity. We obtained the velocity of the sun that maximizes correlation between observations and predictions. Our value is $V = 365\,\text{km/s}$, $R.A. = 81° = 5\,\text{h-}24\,\text{m}$, Dec. $= 79°$ or in galactic coordinates $(l, b) = (134°, 23°)$ (average correlation 71% and standard deviation 15%). This may be compared to the velocity of earth obtained in the COBE experiment: $V = 365 \pm 18\,\text{km/s}$, $(l, b) = (265°, 48°)$, i.e., same speed but different direction.

1. INTRODUCTION

By the end of the 19th century, Poincaré and other writers suggested the hypothesis that the translational motion of earth could not be detected by experiments carried out in our terrestrial laboratory. Within a few decades Poincaré's hypothesis became enthroned as a dogma. The claimed null result of the 1887 Michelson-Morley experiment (MM in the following) [1] was one of the few empirical evidences — certainly the most quoted one — supporting Poincaré's conjecture. Since the beginning of the 20th century Miller [2] claimed that neither the original MM experiment nor his own repetitions were null, but his warnings were ignored.

By considering the circle described by the apex of the motion, Miller introduced a scaling factor to amplify the small observed fringe-shift [2], and obtained two possible values for solar velocity:[1]

- Velocity to the north: Speed $V = 200\,\text{km/s}$, right ascension $\alpha = 17\,\text{h}$, declination $\delta = +68°$, announced at the Pasadena Conference in 1927 [2].
- Velocity to the south: Speed $V = 208\,\text{km/s}$, $\alpha = 4\,\text{h-}54\,\text{m}$, $\delta = -70°\text{-}33'$, obtained from a re-analysis of data by the end of 1932 [2]. In his final paper Miller [2] opted for the solar motion towards the southern apex.

2. BRIEF DESCRIPTION OF OUR PREVIOUS WORK

We have previously revised all the initial MM-type experiments up to the early 1930's [3], and found that the experimenters always *observed* small variations in the velocity of light, that were *interpreted* as zero. Further weaknesses in the design, operation and data reduction of both the MM and Miller experiments were also uncovered [4, 5]. Rather than entering into endless controversy regarding the original experiments, we opted for the positive approach of repeating the MM experiment, using Miller's approach of continuous measurement. To improve resolution and decrease experimental error, our interferometer is at rest in the laboratory.

For a given velocity of the sun (speed and direction), it is easy to predict the expected fringe-shift in a stationary interferometer located at some latitude, as function of the month of the year

[1]The interpretation of the observations of any interferometer experiment admit two different velocities of solar motion.

and the time of day. If the calculations are made using Galilean addition of velocity, there are 24-hr periodic variations of the fringe-shift, superimposed upon annual variations [6]. Since Einstein's restricted theory of relativity (RTR) predicts no variation in the fringe-patterns, a consistent and reproducible observation of periodic variations (after subtracting environmental and other periodic effects) falsifies both Poincaré's conjecture, and Einstein's second postulate of RTR.

The measurements reported in this paper were made with a symmetric interferometer with equal arms (2.044 m each one), oriented West-East and South-North upon a 13,000 kg concrete table. The light source was a green Nd:YAG diode pumped laser, wavelength = 532 nm. A photograph of the interference pattern was captured with a video camera and recorded every minute into a computer placed outside the concrete table, so that 1,440 readings were obtained every 24 hours. Temperature of the table, and temperature and humidity along each arm were recorded every 3 minutes; for further details see [7, 8].

Observations started in January 2003 and lasted until February 2005. Each session ran from late afternoon of each Friday to the mid-morning of next Monday. The objective being to operate when students and personnel were not in the building housing the apparatus. Noting the stability of the fringe-shift curves, by the end of 2003 it was decided to operate the apparatus during the working week, thus increasing the duration of each observational session. Operation Data was periodically downloaded from the computer onto a CD, for a total of 311 CDs (700 MB each).

For each month, a several-day session by the middle of the month was selected. Each interference pattern is converted into a brightness intensity profile, where bright fringes correspond to maxima, and dark fringes to minima. The pixel-position of a reference dark fringe was plotted against time, clearly depicting 24-hr periodic variations, as already reported elsewhere [7–9]. The amplitude of the variations was as large as 20 fringes, and was correlated to the environmental variations of temperature, humidity and pressure. The component of the signal that was stochastically correlated with the environmental variables was subtracted, to get a residual with a significant amplitude of several fringes, and still depicting a 24-hr periodicity. *The residual is no longer significantly correlated with the environmental variables.* A several day session is then averaged over a single 24 sidereal hours period, which is representative of each month. A total of 24 series for 24 months between January 2003 and February 2005 (no data for May and June 2004).

It may be stressed that our room was not environmentally controlled, but that the stochastic correction procedure that was applied tends to over-correct, and to decrease the amplitude of the residual, i.e., it is on the safe side to avoid artifact signals. Also note that such corrections were not even envisaged at the time of Michelson-Morley and Miller experiments.

During 2005–2007 we concentrated on checking the existence of periodic 24 hr variations in the residual fringe-shifts, linked to the varying projection of solar motion upon the plane of the interferometer [7, 8]. In 2007 we tackled the calculation of the solar velocity that best fits our data [10]. Following Miller [2], we focused on the southern solution (recall footnote 1) to obtain a solar motion with speed $V = 500\,\text{km/s}$, $\alpha = 250^\circ = 16\,\text{h-}40\,\text{m}$, $\delta = -75^\circ$. The average correlation for the 24 series was $R = 0.55$, with standard deviation 0.29, which is not particularly good. Here we report the other possible solution, solar motion towards the northern apex, which is significantly better, as described next.

3. MOTION OF SUN TOWARDS THE NORTHERN CELESTIAL POLE

The 24 individual monthly series were reduced to 12 series, one for each month of the year. The 3 series corresponding to January 2003, 2004 and 2005 were averaged, and the same for February 2003 through 2005. For the other months the two series for years 2003 and 2004 were averaged, excepting May and June that were only available for year 2003. Figure 1 shows 4 typical monthly averages.

Note that some months are followed by the word "flip", or by the letter "F". In his analysis of the original MM experiment, Hicks indicated in 1902 [11] that to produce interference patterns, one of the reflecting mirrors cannot be perpendicular to the interferometer arm. The mirror is tilted during the process of calibration and focusing of the interferometer. Depending of the direction of tilting, the interference pattern may move "up" or "down". This was one of the errors made by MM in their data reduction, whereby they averaged measurements from different days, without paying attention to the sign of the tilting [3]. In our case, the motion of the fringe is determined by the pixel position. In the case of vertical interference patterns the fringes move horizontally to the right or to the left, while in the case of horizontal interference patterns the fringes move up or down. For the computer program, it was arbitrarily assumed that motion of the fringe to the right

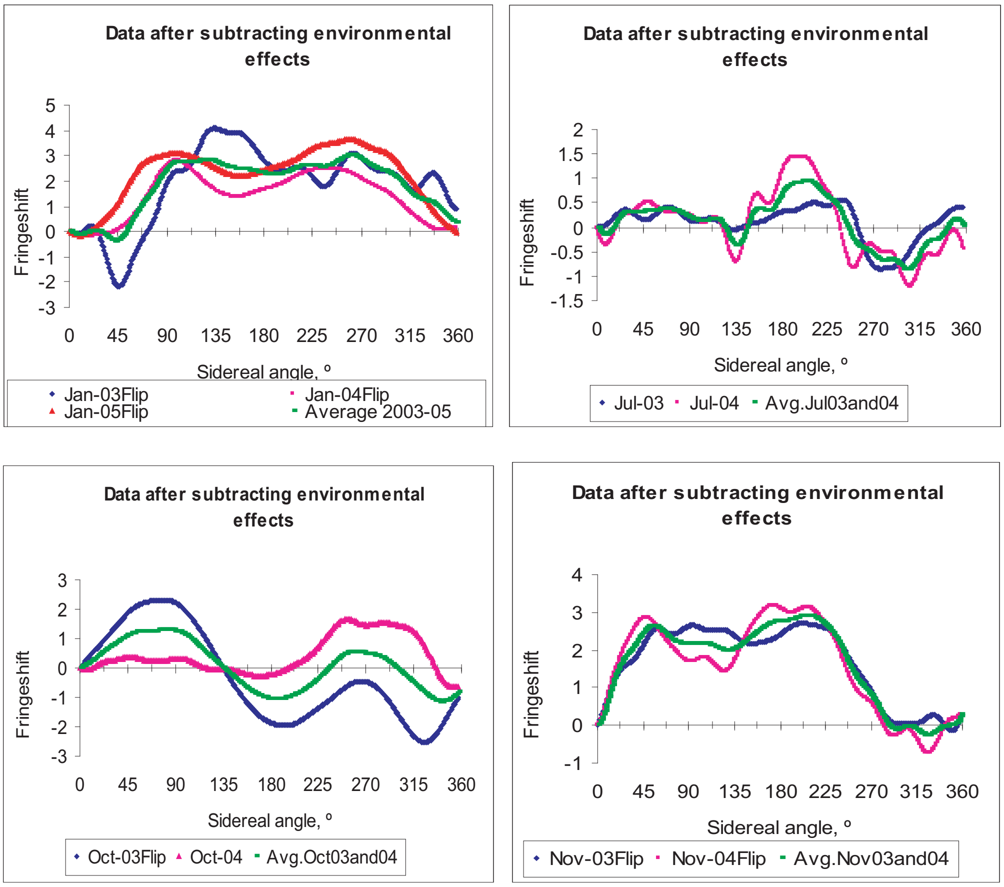

Figure 1: Four examples of the monthly data after subtracting environmental effects (pressure, humidity and temperature). The green curve is the average for a given month in years 2003 and 2004. For January and February the average is for three years.

(respectively, upwards), corresponded to the fringe shifting upwards, and that motion to the left (respectively downwards) corresponded to the fringe shifting downwards. However, the opposite convention could also be used. This produces a "flipping" of the curve, i.e., a change of sign. To avoid falling into the same trap as MM, we carefully consider for every month the correlation most consistent with the curves for different years. In some cases it was necessary to "flip" the curve produced by the computer program. For the velocity solution towards the southern celestial pole, that was made in 2007 [10], all the averages in Figure 1 must be flipped.

The curves in Figure 1 are residual curves, so that an error bar should be assigned to them. Temperature and humidity were measured at 3 minutes intervals, and correlated to fringe-shift. Using the slope of this correlation, the fringe-shift that can be attributed to the environmental variable was subtracted. To correct for pressure during year 2003, we made correlation with the data taken by the meteorological station at the Eldorado airport, some kilometers away from the campus of National University. This process was not easy because the airport data was taken at sixty minutes intervals, while our measurements were every minute. To avoid this difficulty, to correct during years 2004 and 2005 we constructed synthetic pressure curves using historical data taken over a 30-year span at a station in the campus of the University. It is our feeling that the effort to calculate error bars for Figure 1 is not worthwhile, for there are too many assumptions.

For each month we calculated the expected fringe-shift versus time of day, as a function of the velocity of the sun with respect to a *preferred frame* where light moves with constant speed c, independently of direction and of the state of motion of the light emitter. The correlation R between the observed (i.e., the average in Figure 1) and the calculated curves was obtained, and the average R for the 12 months calculated. The aim was to obtain the value of solar velocity that best adjusts to our observations in Figure 1. Two criteria were used:

- Criterion 1. Obtain the solar velocity (i.e., speed V, right ascension α, and declination δ) that maximizes the value of average R.

- Criterion 2. Obtain the solar velocity (V, α, δ) that minimizes the dispersion of R, as measured by the standard deviation of R.

The results of both optimizations are in Table 1. It may be noted that solar velocity is not very sensitive to the optimization criterion. It comes as a surprise that the solar speed $V = 365\,\mathrm{km/s}$ coincides with the value reported by the COBE experiment for the motion of earth with respect to the CMB [12], while the directions approximately differ by 90°. The average correlation is now around 70% which is a significant improvement with respect to the southern motion solution that was reported last year [10]. The standard deviation of R is now less than one-half the value previously obtained for the motion towards the southern celestial pole. Our data is consistent with solar motion towards the northern apex with speed $V = 365\,\mathrm{km/s}$, $\alpha = 81° = 5\,\mathrm{h}\text{-}24\,\mathrm{m}$, $\delta = +79°$.

Table 1: Solar velocity adjusting best to observations.

Solar Velocity	**Criterion 1**	**Criterion 2**
V, km/s	365	366
Right ascension, $\alpha°$	81	78
Declination, $\delta°$	79	75
	Correlations between observation and prediction	
Observation month	Maximize average R	Minimize Std. Dev. of R
January	0.883	0.749
February	0.677	0.564
March	0.806	0.883
April	0.729	0.746
May	0.721	0.617
June	0.783	0.742
July	0.768	0.746
August	0.804	0.803
September	0.847	0.836
October	0.381	0.478
November	0.636	0.684
December	0.494	0.547
Average $R\,()$	0.711	0.699
Std. Dev. $R\,()$	0.147	0.124

Although error bars were not calculated for our data, we carried out a sensitivity analysis for our results to find that our data is consistent (with average correlation higher than 70%) with velocities in the range determined by $250\,\mathrm{km/s} \leq V \leq 680\,\mathrm{km/s}$, $73° \leq \alpha \leq 88°$, and $74.5° \leq \delta \leq 82°$. The robustness of our findings to small variations in the selection of the data was also checked. Figure 2 compares observation versus prediction for criterion 1, for the four months considered in Figure 1, which include the months with lowest (October) and highest (January) correlations R shown in Table 1.

4. COSMIC VELOCITY OF SUN

From the foregoing it may be confidently stated that our observations from January 2003 to February 2005 are consistent with motion of the sun in a preferred frame with speed $V = 365\,\mathrm{km/s}$, in the direction $\alpha = 81° = 5\,\mathrm{h}\text{-}24\,\mathrm{m}$, $\delta = +79°$. Average correlation between observation and prediction is better than 70%. In galactic coordinates[2] the direction of motion is longitude $l = 134°$, latitude $b = 23°$, which may be compared to velocity of earth with respect to the CMB obtained by Smoot and collaborators [12, 13], say $V = 365 \pm 18\,\mathrm{km/s}$, $(l, b) = (265°, 48°)$. Figure 3 shows various velocities of the solar system with respect to an external frame. It is a remarkable coincidence

[2]The NASA/IPAC Extragalactic data base was used for the conversions.

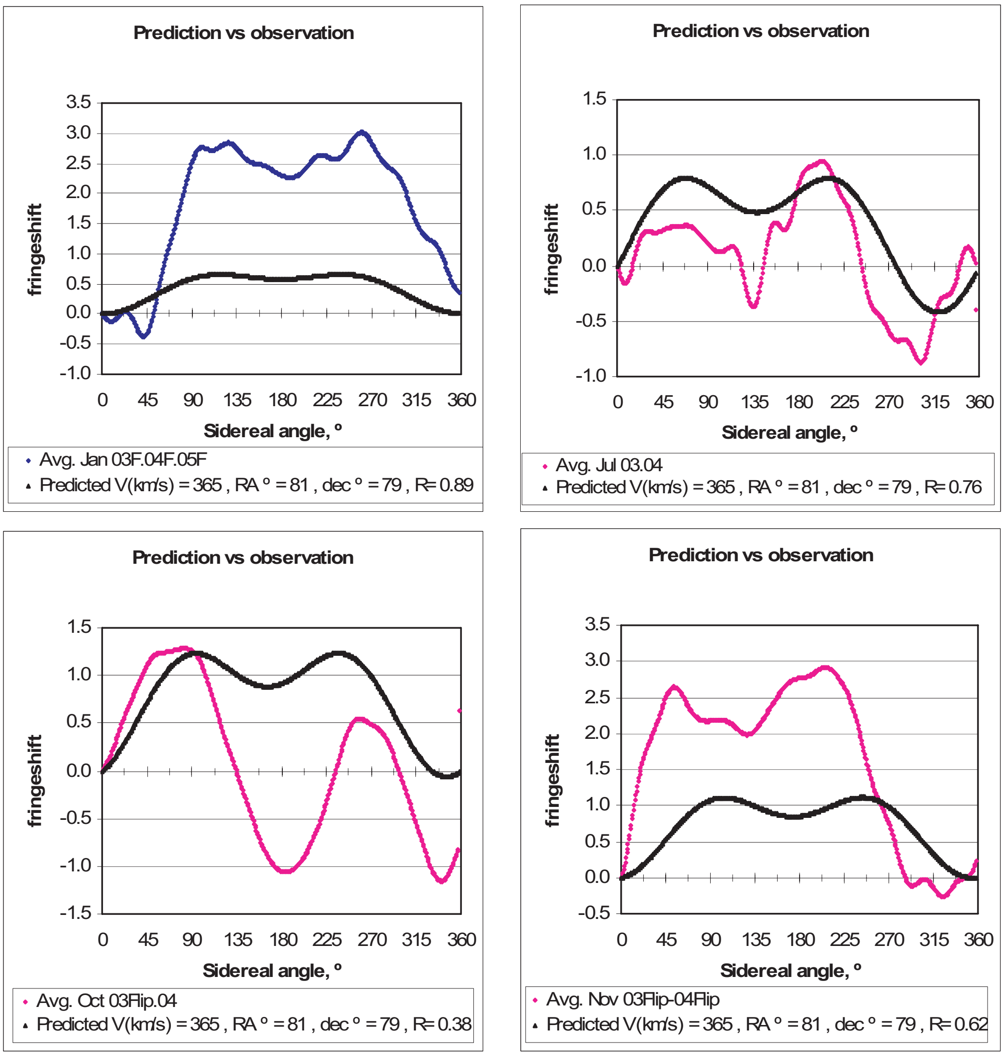

Figure 2: Prediction versus observation for solar velocity. Calculations are for $V = 365\,\text{km/s}$, $\alpha = 81°$, $\delta = 79°$, obtained from application of criterion 1 (maximum average correlation) to our data.

that the optical measurements seem to concentrate on a plane containing $\alpha = 75$ and $\alpha = 255°$, while the CMB-type measurements are on a direction almost perpendicular to this plane. The explanation of this finding is an open question. On the contrary the values of V are completely compatible.

A recent measurement of earth's cosmic motion made by Cahill, using the one-way speed of electromagnetic waves in a coaxial cable [14], leads to $V = 400 \pm 20\,\text{km/s}$ in the direction $\alpha = 5.5 \pm 2\,\text{h}$, $\delta = -70° \pm 10°$. This value is also included in Figure 3.

The motion of our sun with respect to the centroid of our local group (LG) is given by:

a. Rotation of the sun around the center of our galaxy with $V = 220\,\text{km/s}$, in direction, $(l,\, b) = (90°,\, 0°)$, as recommended by the IAUP, 1959.
b. Peculiar motion of our sun with respect to previous rotation with $V = 16.55\,\text{km/s}$, in direction, $(l,\, b) = (53.13°,\, +25.02°)$.
c. Motion of Milky Way towards Andromeda at $V = 40\,\text{km/s}$, in direction, $(l,\, b) = (121.17°,\, -21.57°)$.

The net motion of our sun with respect to the LG centroid is then $V = 264\,\text{km/s}$, in direction, $(l,\, b) = (92.23°,\, -1.67°)$. Subtracting this value from our solar velocity $V = 365\,\text{km/s}$, $(l,\, b) = (134°,\, +23°)$ we get the velocity of our LG with respect to the preferred frame as $V = 269\,\text{km/s}$, $(l,\, b) = (185°,\, +33°)$. The last value may be compared to the direction of motion of the LG with respect to the CMB that is $(l,\, b) = (77°,\, +30)$. It appears that the motion of the LG centroid obtained with our interferometer is close to a right angle relative to the motion of the LG relative to the CMB (see Figure 3).

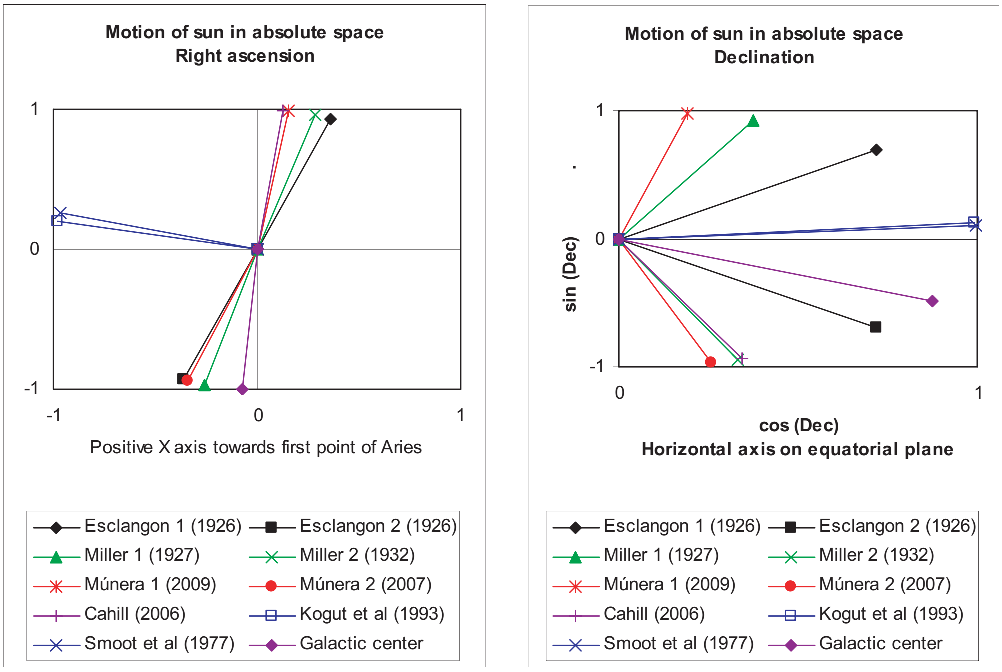

Figure 3: Right ascension and declination of the direction of solar motion. Note that all optical experiments are close to a plane across the origin with $\alpha = 75^\circ = 5\,\mathrm{h}$. The direction of the galactic center is also included for comparison; its right ascension is also compatible with the same plane.

In order to improve our experimental accuracy, currently we are completing at the CIF in Bogotá, the setup of a new experiment with a "one-arm" stationary interferometer housed inside an environmentally controlled chamber (gas of known composition at constant temperature, hence constant pressure). Sensors to determine temperature and absolute pressure will be placed inside the stainless steel chamber housing the interferometer.

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