Redshift of the 21 cm Line from Taurus A near Occultation by the Sun

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Abstract: The 21-centimeter absorption line from the direction of Taurus A showed a shift in frequency when the source passed near Sun. The observed redshift can be explained by an energy loss of electromagnetic waves, when the electric component accelerates unbound electrons in the thin plasma surrounding the sun. A reexamination of the recorded radio signals corroborates the predicted redshift of electromagnetic waves. This allows to determine the number of free electrons in the corona.

Introduction

Since 1907, it is an established but unexplained fact that the wavelengths of the Fraunhofer lines depend on the point of observation an the solar disk[1 2]. The systematic deviation from the predictions of the theory of relativity is amazing and can not be caused by turbulence of the plasma. Not only spectral lines in the optical range[3], even radio signals with significantly lower frequencies (2295 MHz) are red shifted when they traverse the corona close to the sun[4].

Another example is the Hydrogen line (1420 MHz), which is observed frequently in radio astronomy. 47 years ago, on 15 June 1967, the line-of-sight between Taurus A and the earth was passing at 1.25 deg from the sun. Before and after this date, Sadeh el al. monitored the frequency and during the day of closest approach, a decrease in frequency of about 150 Hz was detected[5]. Of course, this was not a single measurement, but an average of 20 individual data points. The redshift cannot be explained by general relativity, which predicts a shift of ± 0.16 Hz. A check in March 1967, when Taurus A was far away from the sun, resulted in small frequency deviation of about ± 20 Hz.

Unfortunately, it is not clear whether the minimum angle (1.25 deg) is to be measured from the limb or from the center of the sun. A calculation with the interim results shown in the paper suggests that Sadeh meant probably the center of the sun. Therefore, the assumed minimum distance between the line-of-sight and the center of the sun in all calculations below is $3.27 \cdot 10^9$ m.

(A) May 29, 2014, email: herbertweidner@gmx.de

Sadeh's data

The picture shows the recorded data of Sadeh without the tentative $1/r^2$ line, for which no physical justification was given.

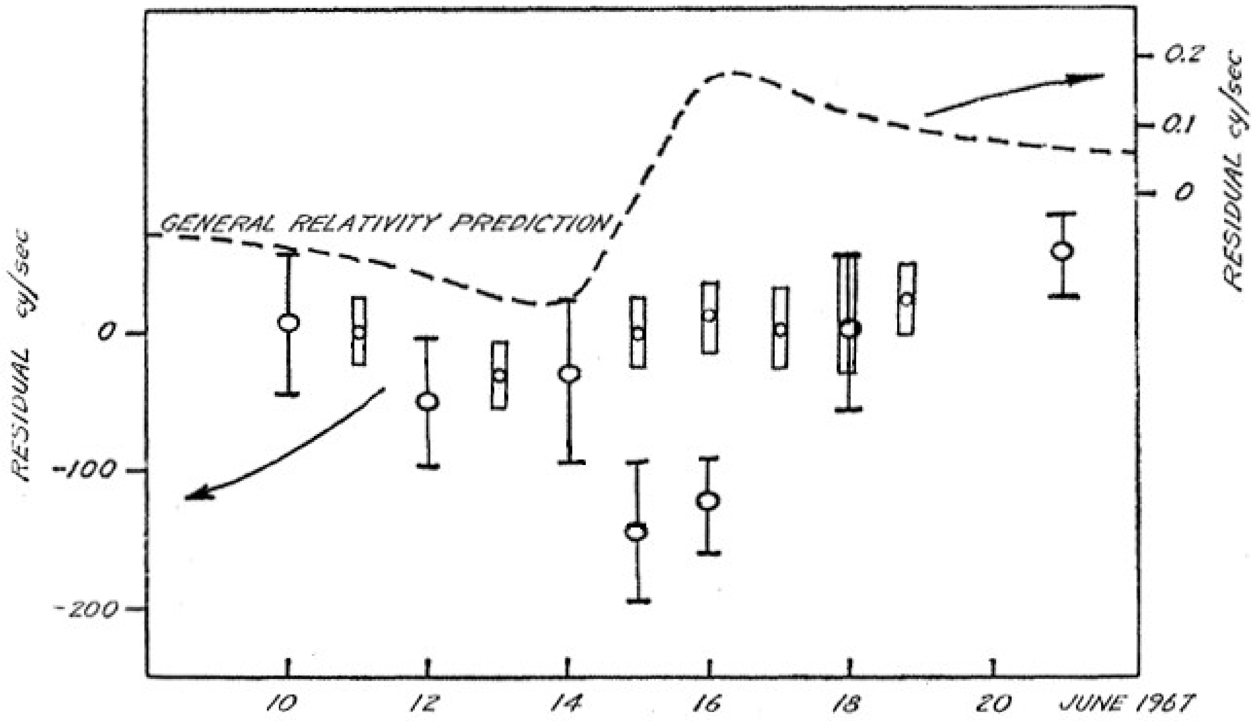
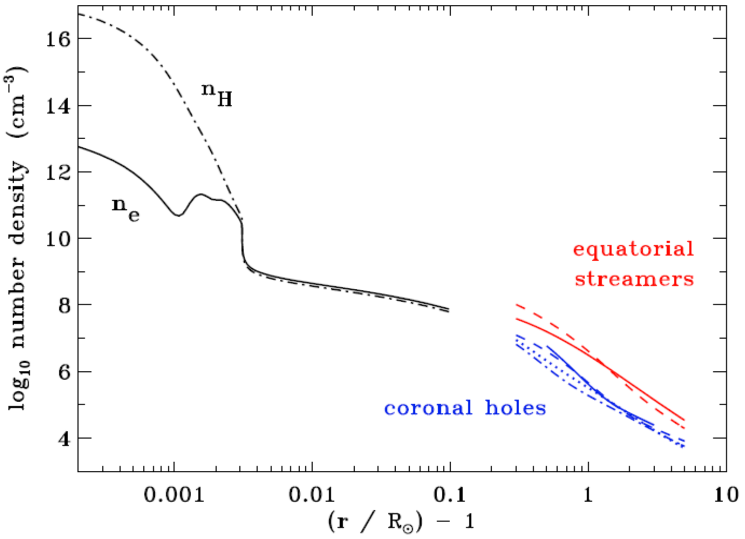


Fig. 1. Circles represent the experimentally determined residual frequency (measured minus calculated) of the 21-cm line during the days before and after the closest approach of Taurus A to Sun. The error flags represent the actual spreads of the 20 measurements of frequency taken each day.

The dashed line is the general relativistic effect of the change of frequncy as Sun approaches the line of sight Earth–Taurus, as predicted for the situation in June 1967. The rectangles represent Taurus-A data received during 7 days of testing between 7 and 15 March 1967, when Sun was far away from Taurus A.

The light path near the solar limb



The sun is surrounded by a thin plasma, whose electron density (ED) decreases with increasing distance. Far outside, the ED is not well known, the estimates differ by more than an order of magnitude[6] [7] as shown in the picture. As explained, every electron is accelerated by the electromagnetic wave and therefore radiates like a dipole antenna. The law of conservation of energy requires that the original electromagnetic wave loses a tiny amount of energy and therefore reduces its frequency[B]. With a single electron, the loss will be hard to

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(B) For a detailed discussion, see [8] and [9] detect. But if the length of the light path in the plasma is long enough, a density of $n_e = 10^5\,cm^{-3}$ produces a measurable drop in energy. Here[8] is shown, that the redshift z can be calculated by

$$z = w\int_0^D n_e\,ds \quad \text{with} \quad w = \frac{3\,q_e^4\,\mu_0^2}{512\,\pi\,m_e^2} = 2.33\cdot 10^{-30}\,m^2$$

Modeling of the Redshift

Taurus A is very far away and does not move apparently. The distance between the line-of-sight and the sun changes because the earth revolves around the sun. The apparent distance between the *line-of-sight* and the sun limb was calculated with the average orbital speed of the earth of $2.58\cdot 10^6$ km / day.

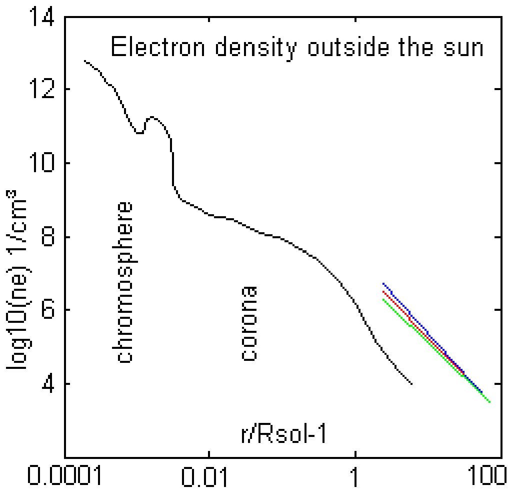
Since the exact absorption frequency of the hydrogen clouds is known, the true redshift can be easily obtained from Sadeh's data. The theoretical redshift was compiled by numeric integration, the program is shown in the appendix. The energy loss is summed from the point of closest approach to the maximum distance $70\cdot R_{Sun}$. The additional redshift due to the remaining distance is ignored.

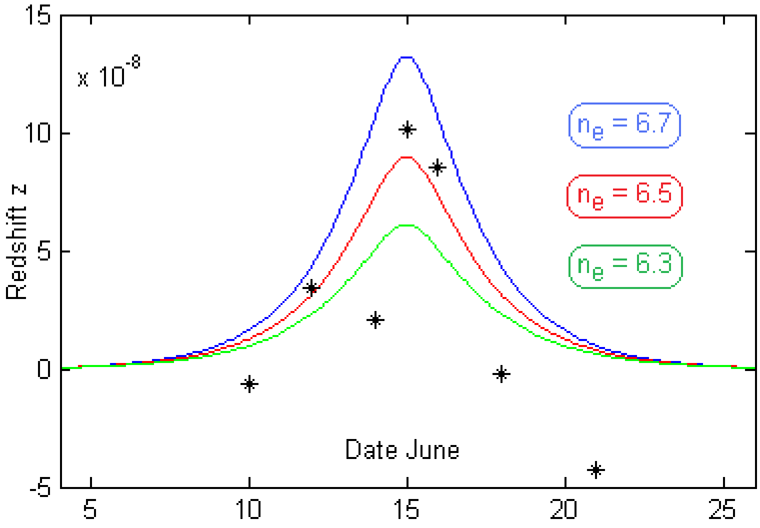
The electron density at distances greater than $2\cdot R_{Sun}$ is not accurately known and may be chosen arbitrarily. The selected values strongly influence the calculated energy loss and thus the redshift. As a first step, the ED is chosen at the end points of the range $2.5\cdot R_{Sun} \rightarrow 70\cdot R_{Sun}$. The local values for the ED are linearly interpolated between the two end points.

Distance from the center of the sun	$\log10(n_e)$ (cm^{-3})
$2.5\cdot R_{Sun}$	6.55
$70\cdot R_{Sun}$	3.50

These estimates may be changed, they are stored in table *nex* (program lines 8 and 9). The consequences of the change will be displayed graphically.

The optimal result is shown in the picture. The left part of the black curve shows the electron density, which is based on the model of Avrett and Loeser[7], the values are considered to be backed up. The right part of the black curve is estimated and hardly substantiated by measurements. Large uncertainties must be expected. Using numerical integration in the program *TaurusA*, the red-colored straight line near the right edge shows the result for best match ($n_e = 6.5\cdot 10^{-8}\,cm^{-3}$) between measured and calculated data for the redshift. The green or the blue line differ only slightly from the optimal red line. But the much poorer agreement with the resulting model data with Sadeh's data shows (in the next picture) that the electron density in the corona can be determined quite exactly by measuring the redshift of electromagnetic waves.





This picture shows the best fit of the theoretical redshift $6.5\cdot10^{-8}$ cm^{-3} (red). The quality of the match can be judged hardly because Gadeh has measured too few data points (black stars without error bars). On the basis of statistical analysis, he has calculated a probability of only 90% that this is a real increase in redshift.

The match was achieved by varying only *two* parameters in the program *TaurusA*, because the frequency of the hydrogen line is known. The two parameter are the electron densities in height $2.5\cdot R_{Sun}$ and $70\cdot R_{Sun}$.

In contrast, the modeling of the *Pioneer 6 Anomalous Redshift*[4] required the third parameter *z-offset*, because the exact transmitting frequency of Pioneer 6 is unknown.

A more detailed inspection requires more measurement points, which can only be obtained by a repetition of Goldstein's experiment. With the data, the structure and the electron density of the corona could be determined.

In order to explain a frequency change of an electromagnetic wave, so far only the Compton effect has been taken into consideration. This explanation applies at frequencies above 10^{16} Hz, perhaps even in UV light. In visible light, the Compton effect is no longer detectable. At 1420 MHz, any explanation with Compton effect is nonsense because the rest mass of the electron is much too large. Quantum mechanics offers no explanation, but with the proven methods of classical mechanics, the frequency change can be described without problems[9]. Gadeh was the first to detected the frequency reduction of radio wave when they traverse the corona. The test should be reproducible at any time.

The most likely cause of the observed Redshift is an energy loss of the radio waves when they pass through the plasma of the corona. If the distance between the *line-of-sight* and the Sun decreases, the plasma density increases. Every unbound electron (the plasma is 100% ionized) slightly reduces the energy of traversing electromagnetic waves. According to classical physics, the energy loss can not be avoided, it is described here[8] in detail. According to quantum mechanics, there is no loss of energy because Photons never reduce their frequency when they pass through thin plasma.

Appendix: Programs for MATLAB

The file “TaurusA.zip” contains the program “TaurusA” and the necessary data. It may be requested by mail from herbertweidner@gmx.de

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%TaurusA, Herbert Weidner, 29 May 2014
%nearest approach to the sun: 15 June 1967)
fe=[100 120;0 191;-200 333]; %calibration of frequency
load Sadeh1 %ne %contains data from Avrett Loeser 2008
%ne(:,1) %=r/Rsol-1, r=height over photosphere
%x=ne(:,2); %=log10(r/Rsol-1)
%y=ne(:,3); %=log10(ne) %local density
nex(1,1)=2.5; nex(1,2)=log10(nex(1,1)); nex(1,3)=6.55; %guessed
nex(2,1)=70; nex(2,2)=log10(nex(2,1)); nex(2,3)=3.5; %guessed
figure(1)
plot(ne(:,2),ne(:,3),'k',nex(:,2),nex(:,3),'r')
xlabel('log10(r/Rsol-1)')
ylabel('log10(ne) 1/cm³'), title('Electron density outside the sun')
hold on
%scatter(Sadeh(:,3),-Sadeh(:,4)) %raw differences from ref-line
Sadeh(:,5)=interp1(fe(:,2),fe(:,1),Sadeh(:,4));
Sadeh(:,6)=-Sadeh(:,5)/1420e6; %f(Hydro)=1420 MHz
Rsol=700e6; %m
w=2.33e-30; %[m²]
for x=1:size(Sadeh,1)
    Sadeh(x,8)=x; %10*Date
    y=(Sadeh(x,2)/Rsol):0.02:nex(2,1); %divide into small pieces
    nem = 10.^interp1(nex(:,1),nex(:,3),y); %local density
    z=2*sum(w*1e6*nem.*(y(1,2)-y(1,1))*Rsol); %cm³->m³, Hin+Rückweg
    Sadeh(x,7)=z;
end
figure(2),plot(Sadeh(:,8)/10,Sadeh(:,7),'r') % calculated z
xlabel('Date June'), ylabel('Redshift z'), title('computed Redshift')
hold on
scatter(Sadeh(:,8)/10,Sadeh(:,6),'k','*') % measured z
title('Taurus A'), xlabel('Date June'), ylabel('Redshift z')
%finito
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