Cosmological Redshift Interpreted as Gravitational Redshift

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Distant redshifted SNe1a light sources from the Universe that are usually interpreted as cosmological redshifts are shown to be universal *gravitational* redshifts seen by all observers in the quantum celestial mechanics (QCM) approach to cosmology. The increasingly negative QCM gravitational potential dictates a non-linear redshift with distance and an apparent gravitational repulsion. No space expansion is necessary. QCM is shown to pass the test of the five kinematical criteria for a viable approach to cosmology as devised by Shapiro and Turner, so the role of QCM in understanding the behavior of the Universe may be significant.

1 Introduction

The observed redshift from distant sources can be interpreted as (1) a velocity redshift called the Doppler Effect, (2) a cosmological redshift in which space itself is expanding during the transit time of the photons, and/or (3) a gravitational redshift as introduced by the General Theory of Relativity (GTR). High-z redshifts from distant SNe1a light sources in galaxies are presently being interpreted as cosmological redshifts, apparently providing observational evidence for the expansion of the Universe.

A new theory, Quantum Celestial Mechanics(QCM), developed from GTR by H. G. Preston and F. Potter [1, 2], accurately predicts the observed SNe1a redshifts from near and distant galaxies. For the Universe, there exists in QCM a previously unknown gravitational potential that is used to derive all of the observed SNe1a redshifts. In addition, QCM predicts no mass currents in any coordinate direction, i.e., no galaxies moving away anywhere. These results eliminate the need for a space expansion. The presently known average baryonic density of the Universe is sufficient for QCM to explain the critical matter/energy density of the Universe.

Observations of galaxies and distributions of galaxies are beginning to suggest conflicts with the standard concept of an expanding Universe and its interpretation of a high-z redshift as a cosmological redshift. For example, galaxies at $z = 2.5$ are reported [3] to be extremely dense when using the expanding Universe assumptions and standard galaxy modeling. However, if the Universe is not expanding, the linear scales of these galaxies would be much larger, eliminating the high density conflict and revealing galaxies much similar to galaxies seen locally.

Theoretical approaches are also beginning to inquire about what we really know about cosmic expansion and its acceleration. In an interesting paper, C. A. Shapiro and M. S. Turner [4] relax the assumption of GTR but retain the weaker assumption of an isotropic and homogeneous space-time described by a metric theory of gravity. Using the Robertson-Walker metric to describe the Universe and accepting the dimming and redshifting of a gold set of SNe1a data [5], they determine the cosmic acceleration kinematically and provide a list of five kinematical criteria that must be met by any approach to cosmology.

In this paper, we compare the QCM predictions for the state of the Universe to the five criteria provided by Shapiro and Turner. Our new result is that QCM agrees with the five criteria. Therefore, SNe1a redshifts can be interpreted as universal *gravitational* redshifts instead of cosmological redshifts. There is no need for space expansion.

2 Reviewing the QCM potential

In a series of papers [1, 2, 6] we derived and applied QCM to the Solar System, to other solar system-like systems such as the satellites of the Jovian planets and exoplanet systems, to the Galaxy, to other galaxies in general, and to clusters of galaxies [7]. In all these cases there is reasonable agreement with the observational data, i.e., the predicted QCM states of the gravitationally-bound systems were shown to be actual states of the systems without the need for dark matter. Recall that the QCM general wave equation derived from the general relativistic Hamilton-Jacobi equation is approximated by a Schrödinger-like wave equation and that a QCM quantization state is completely determined by the system's total baryonic mass M and its total angular momentum H_Σ.

These agreements with the data strongly suggest that QCM applies universally and that all gravitationally-bound systems should obey the quantization conditions dictated by QCM. Therefore, not only should the large-scale gravitationally bound systems like a solar system exhibit QCM behavior, but even a torsion balance near an attractor mass should have quantization states. And the largest gravitationally-bound system of all, the Universe, should also be describable by QCM. The QCM states of a torsion bar system will be discussed in a future paper. In this paper we concentrate on the QCM Universe.

For gravitationally-bound smaller systems, we found that the Schwarzschild metric approximation produced an efffective gravitational potential for a particle of mass μ in orbit

$$V_{\text{eff}} = -\frac{GM}{r} + \frac{l\,(l+1)\,H^2c^2}{2r^2}\,, \tag{1}$$

where G is the gravitational constant, c is the speed of light in vacuum, the characteristic length scale $H = H_\Sigma/Mc$, the angular momentum quantization number l originates from the θ-coordinate symmetry, and r is the r-coordinate distance from the origin in spherical coordinates. Therefore, in QCM the total angular momentum squared is $l\,(l+1)\mu^2H^2c^2$ instead of the classical Newtonian expression. Consequently, the quantization of angular momentum dictates which particular circular orbit expectation values $<r>$ in QCM correspond to equilibrium orbital radii, in contrast to Newtonian gravitation for which all radii are equilibrium radii.

In the case of the Universe we used the GTR interior metric approximation, which is directly related to the general Robertson-Walker type of metric. Omitting small terms in the r-coordinate equation, we derived a new Hubble relation that agrees with the SNe1a data. At the same time we showed that our QCM approach produced the required average matter/energy density of about 2×10^{-11} J/m^3, corresponding to the critical density $\rho_c = 8\times10^{-27}$ kg$\times$m^{-3}, with only a 5% contribution from known baryonic matter, i.e., without needing dark energy.

The QCM effective gravitational potential for all observers inside a static dust-filled, constant density universe with no pressure is

$$V_{\text{eff}} \approx -\frac{kr^2c^2}{2\,(1-kr^2)^2} + \frac{l\,(l+1)H^2c^2}{2r^2(1-kr^2)}\,, \tag{2}$$

where $k = 8\pi G\rho_c/3c^2$. Figure 1 shows this QCM gravitational potential for an r-coordinate distance up to about 10 billion light-years.

If the total angular momentum of the Universe is zero or nearly zero, H can be ignored and then the negative gradient of the first term in V_{eff} produces an average *positive* radial acceleration

$$<\ddot{r}> = kc^2\,\frac{r\,(1+kr^2)}{(1-kr^2)^3} \tag{3}$$

from which we derive a new Hubble relation

$$<\dot{r}> = r\,\frac{c\sqrt{k}}{1-kr^2}\,. \tag{4}$$

For r-coordinate distances up to about one billion light-years, when $kr^2 \ll 1$, we recover the standard Hubble relation and have a Hubble constant $h \sim 2\times10^{-18}$ s^{-1}, about 62 km per second per megaparsec, an acceptable value [8]. Without the kr^2 in the denominator, $v/c \to 1$ at about 14.1 billion light-years; otherwise, the maximum visible coordinate distance $r = 8.74$ billion light-years, with more of the Universe beyond this distance.

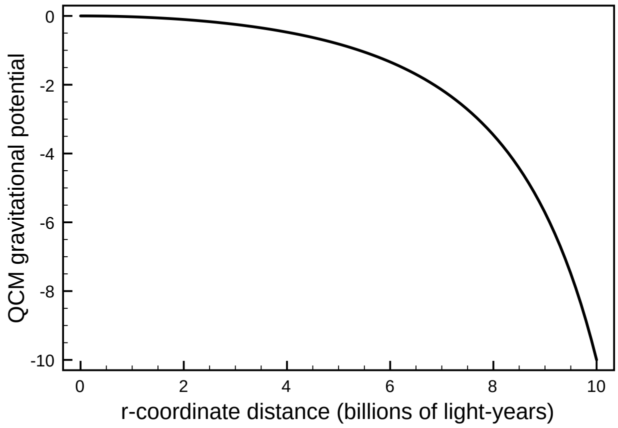

Fig. 1: QCM gravitational potential to 10 billion light-years.

Notice that the QCM effective gravitational potential is negative (when H can be ignored) but produces an apparent *repulsive* gravitational radial acceleration! Each observer anywhere in this Universe will determine that the incoming photons are redshifted. Why? Because the photons originate in a source that is in a more negative gravitational potential where the clock rates are slower than the clock rates at the observer. And this redshift increases non-linearly because the potential becomes more negative more rapidly with increasing distance away. There is no need for expansion of space and its cosmological redshift to explain the SNe1a data. There is no need for dark energy to explain the accelerated expansion.

3 The kinematical criteria

Our QCM approach to cosmology and an understanding of the behavior of the Universe must meet specific kinematical criteria. By analyzing the gold set of SNe1a data, Shapiro and Turner list these five kinematical criteria to be met by any viable approach to a cosmology:

1. Very strong evidence that the Universe once accelerated and that this acceleration is likely to have been relatively recent in cosmic history.
2. Strong evidence that the acceleration q was higher in the past and that the average dq/dz is positive, where z is the redshift.
3. Weak evidence that the Universe once decelerated, but this result may be a model-dependent feature.
4. Little or no evidence that the Universe is presently accelerating, i.e., it is difficult to constrain q for $z < 0.1$ with SNe1a data.
5. No particular models of the acceleration history provide more acceptable fits to the SNe1a data than any

others, i.e., several different kinematic models fit the data as well as the cold dark matter hypotheses called ΛCDM and wCDM.

The QCM effective gravitational potential V_{eff} and the new Hubble relation provide QCM explanations for these five criteria:

1. The light now just reaching us from farther and farther away exhibits an increasing redshift because the V_{eff} is increasingly more and more negative with increasing distance. Without QCM, the interpretation would be that the acceleration is recent.
2. The V_{eff} is increasingly more and more negative with increasing distance. Without QCM, a higher acceleration in the past is required for the space expansion approach to cosmology.
3. QCM shows no deceleration at the level of mathematical approximation we used.
4. The new Hubble relation of QCM reduces to the linear dependence of the standard Hubble relation for z small, agreeing with there being no acceleration presently.
5. Our QCM approach fits the SNe1a data as well as the other approaches, producing about a 12% increase from the linear Hubble when $kr^2 \sim 0.11$, consistent with the data.

QCM explains the five criteria in its unique way because the SNe1a redshift now originates in the properties of the static interior metric and its QCM gravitational potential. The important consequence is that QCM cannot be eliminated by any of the five criteria and must be considered as a viable approach to cosmology.

4 Final comments

The existence of a *repulsive* gravitational potential in the QCM wave equation for the Universe removes the necessity for invoking dark matter and dark energy. According to QCM, the Universe is not expanding and does not require dark energy in order for us to understand its behavior. Previously labelled cosmological redshifts are actually gravitational redshifts of the photons reaching us from distant sources in the Universe that are in greater negative gravitational potentials than the observer. Each and every observer experiences this same behavior. This static Universe is always in equilibrium.

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