Dark Energy – the key to understand the Universe

(*abstract of „O. Beer, Dunkle Energie und Kosmos, Cuvillier Verlag, 2019, Göttingen")*

Following results and analyses of cosmic observations have been taken as basis in this research project

- The total mass of the baryonic or normal matter is n·10^{53} kg (with n about 0,1 to 10)
- Dark matter exists and is about 5.5 times the mass of the normal matter
- A Big Bang happened about 13,8 10^9 years ago
- The distance to and between far away celestial bodies has increased and is still increasing since the Big Bang

The fact, that the distance between far away celestial bodies is increasing or has increased against the gravitation is interpreted in this paper as being caused by a force acting on these celestial bodies, accelerating them and causing the increase of distance between them. The physical principle "actio et reactio" can be interpreted such that if a force is acting on particles with mass then it originates also from particles with mass ("exchange force carrier") This principle of physics, valid on earth for any force, shall also apply to the force responsible for the increase of distance between celestial bodies. In the standard model of the cosmos this increase of distance is due to an expansion of the space, caused by a mysterious energy, the so called Dark Energy. We use this term also in the present paper, as the effect of this dark energy - the increase of distance - is the same in both approaches. According to our above conclusion a so far unknown matter shall be attributed to the dark energy, arbitrarily labeled with m(-). The "dark energy" is then the exchange force between m(-) and normal matter and responsible for the increasing distance between stars.

In addition to the dark energy the cosmos contains the so called dark matter, which is attractive to normal matter. According to above principle it also originates from particles with mass. The charge of the dark matter can be called mass and has the same gravitational properties as the normal matter, attractive with the gravitation constant G to itself and to normal matter. Due to same gravitational behavior we label both, dark matter and normal matter as m(+).

In order to gain information about the interacting forces between m+) and m(-) matter we analyze - for reason of simplicity - a sphere shaped volume containing both types of matter in a homogenous distribution. Such volume can e.g. be obtained when going back in time from the present cosmos to a sufficient prior stage, close after or before the Big Bang. As this volume shall represent the cosmos, we know about the m(+) particles two facts: Firstly, they are subject to gravitation between themselves. Secondly, in spite of the gravitation they are expanding. Taking the interactions between m(-) and m(+) matter as the cause for this expansion, following conclusions result:

- The force between m(-) and m(+) particles must be repulsive, long range (i.e. going with1/r^2) and cumulative, otherwise no expansion whatsoever is possible for the m(+) particles
- The force between the m(-) particles themselves must be attractive, cumulative and long range, otherwise the m(-) particles would have higher centrifugal velocities than the m(+) particles and the latter would contract instead expand

The similarity to the law of gravitation is evident. In particular, if the charge m'(-) of the m(-) matter is renormalized with the help of its attraction constant C^{--} to

$$m_2(-) = \sqrt{\frac{C^{--}}{G}} \cdot m'$$

then the attraction of the m(-) matter to itself is described by the law of gravitation:

$$F = - C^{--} \cdot m'(-) \cdot m'(-) \cdot 1/r^2 = - G \cdot m_2(-) \cdot m_2(-) \cdot 1/r^2$$

The potential U(r) of this volume with radius r is made up by the long range forces of the particles contained therein and is given by (with $M_1(+)$ and $M_2(-)$ as the respective total masses within the radius r)

$$U(r) = 3/5 \cdot 1/r \cdot \left(- G \cdot M_1(+) \cdot M_1(+) - G \cdot M_2(-) \cdot M_2(-) + 2 \cdot C^{-+} \cdot M_2(-) \cdot M_1(+) \right) \qquad (1a)$$

the Potential P(r) of a mass point m(+) at the radius r is

$$P(r) = 1/r \left(-G \cdot M_1(+) \cdot m(+) + C^{-+} \cdot M_2(-) \cdot m(+) \right) \qquad (1b)$$

As an important feature the process of expansion could have started from an equilibrium state. As necessary and sufficient condition for such equilibrium state the potentials U(r) and P(r) must be zero for any radius r.This implies besides homogenous distribution of the matter, that $M_1(+)$ is equal to $M_2(-)$, and that the attraction constant C^{-+} between $M_2(-)$ and $M_1(+)$ is –G . Further on, all particles must be at rest. If one of these conditions is not fulfilled, then $U(r) \neq 0$ or $P(r) \neq 0$ and the system is unstable, not in an equilibrium state.

Summarizing, an equilibrium state exists under the condition the total mass of the m(+) and m(-) matter in above volume is equal, homogenously distributed and at rest, and further on the long range forces are

- m(+) is attractive with the gravitational constant G to itself and
- m(-) is attractive with the gravitational constant G to itself and
- m(-) is repulsive with the gravitational constant -G to m(+) and vice versa $C^{-+} = - G$

The only - albeit reasonable - hypothesis of the cosmos model of this research project is the assumption that the just described equilibrium state is the state of the cosmos before the Big Bang. In this paper this hypothetical spherical equilibrium state is called Urraum (the prefix "Ur" has in German the meaning of "oldest", "prehistoric", "primal". See also the German word for the Big Bang: "Urknall" meaning "Ur-Bang")

The assumption of an equilibrium state has the immeasurable advantage, that the principle of energy and mass conservation also applies to the Big Bang, as the Urraum contains already all matter. Further on, it has the advantage of being derived by the "normal" physical explication that the increasing distance between bodies is caused by a force acting on these bodies. Last not least, the validity of this assumption has to be judged in the light of resulting. conclusions and their comparison with observations

Based on the principles of energy and momentum conservation it can be shown that the mass of the m(-) matter must also be positive and follow the Einstein relation

$$m(-) c^2 = E \qquad (2)$$

and that transfer of energy between m(+) and m(-) matter by electromagnetic waves, weak or strong nuclear interaction can not take place.

The radius b of the Urraum was presumably very small and is estimated to be below 0,001 lightyears. Assuming nuclear density the radius b would be less than 10^{-4} light years. We have to be aware that here normal matter is less than 10% of the total matter, so any statements about the behavior of normal matter is not possible.

The further conclusions of this work are valid with high accuracy as long as the Urraum radius b does not exceed 10 to 100 light years, the smaller b the higher the accuracy.

Based on this Urraum concept the Big Bang has happened without violation of the energy conservation principle. Once the m(-)-matter started (by whatever reason) to accumulate in the center of the Urraum, an ever increasing separation of m(-) from m(+) matter went on by positive feedback. The more m(-) matter accumulated, the more and the stronger m(-) matter was attracted and the more and the stronger m(+) matter was repelled, setting off a chain reaction. This chain reaction led to the complete separation of the previously homogenous distribution of m(+) and m(-) matter and is the definition of the "Big Bang" in the model of this research project.

This Big Bang resulted in an M(-) nucleus of $n \cdot 10^{53}$ kg m(-) matter and from it radially expanding m(+) matter with velocities close to light speed. The center of the M(-) nucleus can be considered as center of the cosmos, by convenience called point U in this paper (in German called Urpunkt , “Ur-point”). The point U can also be considered as the center of the M(-) nucleus.

The structure of this expanding m(+)-matter can be analyzed using two different inertial systems: the system of the point U and the system of a point E (earth), an arbitrarily located point in the expanding m(+) matter. These two approaches will lead to different views, but nevertheless to a more comprehensive understanding of the cosmos. Therefore the resulting model of the cosmos could be called the "Dual Cosmos" model.

At first, the system of point U shall be analyzed. Based on above the mass of the M(-)-nucleus is equal to the total mass of the expanding m(+)-matter. Due to the big mass of the M(-) nucleus and the rather small distances involved in the early time after the Big Bang, the acting forces on the m(+) matter and resulting accelerations are huge. The radial expanding m(+)matter will reach velocities very close to light speed. As light speed can not be exceeded the all m(+) matter will expand close to light speed, in a very thin shell around the M(-)nucleus. In the following it will be shown that after “initial expansion” the over all m(+)matter averaged deviation from light speed will reach a constant value with high accuracy.

The kinetic energy of the m(+) matter $E_{kin}((m(+),r)$ is given by the difference of its potential energy of the Urraum with radius b and the sphere with radius r after expansion. In the latter case the potential energy is calculated with sufficient accuracy, that all material is located at distance r from point U. Further on, for the calculation of potential energies the rest masses apply $M(-) = M_o(-)$ and $M(+) = M_o(+)$. For the Urraum this is the case by its definition. After expansion to radius r the mass changes due to kinetic and potential energy differences cancel each other out. So we have

$$E_{kin}((m(+),r) = \frac{6}{5}\cdot\frac{G}{b}\cdot M(-)\cdot M(+) - \frac{G}{r}\cdot M(-)\cdot M(+) - \frac{3}{5}\cdot\frac{G}{b}\cdot M(+)\cdot M(+) + \frac{G}{2r}\cdot M^2(+)\,) \qquad (3)$$

and with M(-) = M(+) = M (= M_0)

$$E_{kin}((m(+),r) = \frac{3}{5}\cdot\frac{G}{b}\cdot M^2 - \frac{G}{2r}\cdot M^2$$

On the other side the total kinetic energy of all m+)-matter is given by

$$E_{kin}((m(+),r)/c^2 = M\cdot\frac{1}{\sqrt{(1-u'^2/c^2)}} - M \qquad \text{resulting in}$$

$$\frac{3}{5}\cdot G\cdot\frac{M}{c^2}\cdot\left(\frac{1}{b} - \frac{5}{6}\cdot\frac{1}{r}\right) = \frac{1}{\sqrt{(1-u'^2/c^2)}} - 1$$

As the velocity is extremely close to light speed, and with u' = c - ε' this relation can be simplified to

$$\frac{3}{5}\frac{GM}{c^2}\cdot\left(\frac{1}{b} - \frac{5}{6r}\right) = \sqrt{c\,/2\,\bar{\varepsilon}'}$$

$$\frac{9}{25}\frac{G^2M^2}{c^4}\cdot\left(\frac{1}{b} - \frac{5}{6r}\right)^2 = \frac{c}{2\bar{\varepsilon}'}$$

From original radius b to an ever increasing radius r with r ≫ b the deviation from light speed ε' in the following - by convenience - abbreviated avol (= **a**bweichung **vo**n der **l**ichtgeschwindigkeit or **a**berration to **v**el**o**city of **l**ight) becomes

$$\varepsilon' = \frac{25}{18}\cdot\frac{c^5\cdot b^2}{G^2\cdot M^2}\cdot\left(1 + \frac{10b}{6r}\right) \qquad (4)$$

This means that after expansion of about 1000 times as compared to the radius b of the Urraum the deviation ε' from light speed of the m(+) matter is constant with high accuracy. As formula (4) refers to all m(+) matter this avol ε' is the mean average avol $\bar{\varepsilon}'$ of all m(+) matter.

$$\bar{\varepsilon}' = \frac{25}{18}\cdot\frac{c^5\cdot b^2}{G^2\cdot M^2} \qquad (5)$$

Insertion of $M = n\cdot 10^{53}$ kg results in a mean constant avol $\bar{\varepsilon}'$, averaged over all m(+)-matter in the inertial system of point U

$$\bar{\varepsilon}' = 0{,}68\cdot (b^2/n^2)\cdot 10^{-11} \text{ m/sec}$$

with b as the radius of the Urraum in light years and n as the correction factor for the total mass of the cosmos.

The constant mean avol $\bar{\varepsilon}'$, and therefore also the constant mean expansion velocity $\bar{u}'$ of the m(+)matter will already be achieved after initial expansion to a radius r = p· b light years (with p>1000) and stays constant thereafter. As the expansion is effected with nearly light speed, constant mean velocity $\bar{u}'$ is achieved after a transition time T' of about

$$T' = 10^3 \cdot b/c \text{ years} \qquad (6)$$

Depending on b the transition time is about 0,1 to 10^4 years. Further expansion has negligible impact on the constant, mean avol $\bar{\varepsilon}'$. This is an extremely astonishing result, which has far reaching consequences as will be shown below.

The actual avol values ε' will deviate from the constant mean value $\bar{\varepsilon}'$ and can themselves be considered as constant. They can be described by an arbitrarily defined parameter L representing the variation around the mean value,

$$\varepsilon' = \bar{\varepsilon}' \cdot 10^L \qquad \text{with} \quad -L_1 < L < L_2$$
$$u' = c - \bar{\varepsilon}' \cdot 10^L$$
$$R' = T_0 \cdot (c - \bar{\varepsilon}' \cdot 10^L) \qquad \text{and considering} \quad T' \ll T_0$$

The variation parameter L may vary within a small range e.g. from about -2 to about +3, corresponding to following avol range

$$0.01 \cdot \bar{\varepsilon}' < \varepsilon' < 1000 \cdot \bar{\varepsilon}'$$

The radial distance R' of a particle is the product of its constant velocity u' and the time T_0 passed since the Big Bang .

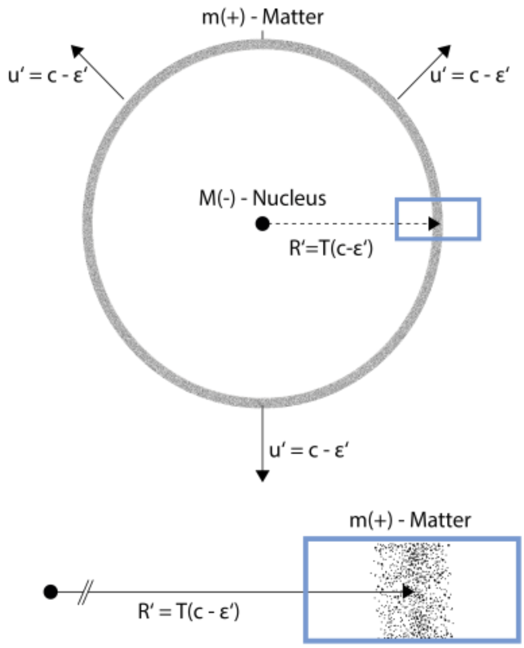

Fig. 1 The expanding Cosmos
After the Big Bang the m(-) matter has been concentrated to an M(-) nucleus in the cosmos. The repulsion to it has caused the spherically symmetric expansion of the m(+) matter, consisting of the normal and dark matter. After a transition time T' the radial expansion velocity u' is constant and extremely close to light speed.

Based on above the m(+)matter is contained in a thin spherical shell with the mean radius $\bar{R}' = T_0 \cdot (c - \bar{\varepsilon}')$ around the point U. See illustration of Fig.1. Its actual radial thickness and shape is determined by the variation parameter L together with a distribution function f(ε') of the avol ε' (see Fig 2). Any mass point in this shell can be described by its velocity u' and its distance R' to point U at a given time T_0 (with $T' \ll T_0$). The velocity u'_{12} between any two points 1 and 2 can be computed by vector addition of its radial velocities u'_1 and u'_2. As u'_1 and u'_2 are constant, u'_{12} is also constant

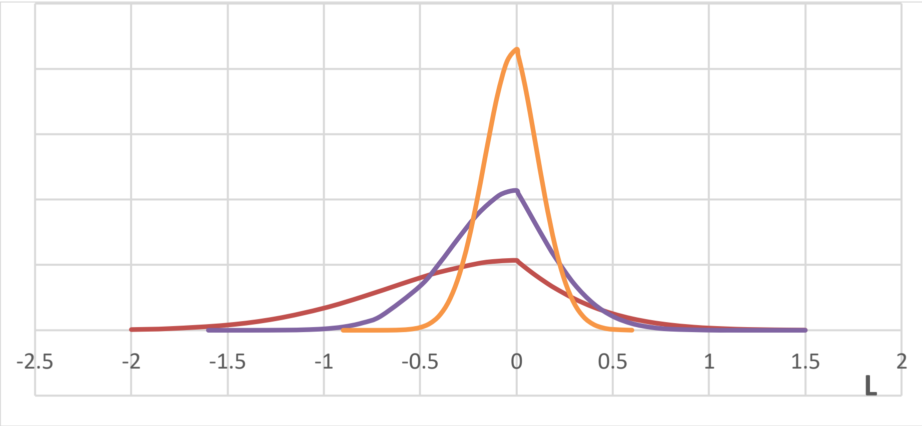

Fig. 2 Examples of possible density distributions
The abscissa shows the range of the variation parameter L, defining the deviation from the mean avol $\varepsilon' = \bar{\varepsilon}' \cdot 10^L$ *with L= 0 corresponding to the mean value. The ordinate shows the density of the m(+) matterin arbitrary units for a given value of the variation parameter L (defining the related avol ε', velocity u' or distance R') .*

It can be stated that the cosmos in the system of point U looks rather strange. All normal matter and dark matter is contained in a very thin spherical shell in a radial distance of about $13{,}8 \cdot 10^5$ light years around point U. How can this strange geometry match to the cosmos, as seen and investigated by an observer on earth???

To this end, one has to analyze how a savant at an arbitrarily chosen point E (earth) in above defined m(+)-shell , will evaluate the velocities of other points in this shell in his own system. The radial velocities are given in the inertial system of point U and must be transformed into the inertial system of point E. Due to the high velocities involved, the velocities in the system of point E must be computed by relativistic addition of velocities, namely $u' = c - \varepsilon'$ of any point S and $v' = c - \varepsilon_0'$ of his own, the latter being at the same time the velocity v = - v' between the two inertial systems. An important feature is the fact, that the radial expansion velocity v' of the point E is itself constant after transition time T'. Therefore the relativistic addition of velocities can be based on the Lorentz-transformation with a constant velocity v between the two systems, avoiding the complexity of the general theory of relativity. Here the use of the entities „avol" shows its benefit as the formula of the relativistic addition of velocities close to light speed will become rather simple.

In the system of point U the coordinates of any point S can be defined in the following way: the x-axis as the straight line from point U to point E and the y-axis as the straight line perpendicular to this x-axis through point S . The constant velocity of any point S after transition time T'can then be factorized into an x and a y component of above defined coordinates. Hereby the y component has rotational symmetry to the x-axis, as it is invariant to the rotation angle φ around the x-axis .

The resulting components of the radial velocity u' = c - ε' of a point S in the point U system are, when ϑ' is the angle between the x-axis and the straight line from point U to point S

$$u'_x = (c - \varepsilon') \cdot \cos\vartheta' = c - c\cdot \vartheta'/2 - \varepsilon' + \varepsilon' \cdot \vartheta'/2 \qquad = c - \varepsilon'_x$$

$$u'_y = (c - \varepsilon') \cdot \sin\vartheta' = \sqrt{(c-\varepsilon')^2 - (c-\varepsilon'_x)^2} = \sqrt{2c(\varepsilon'_x - \varepsilon')}$$

It is to be noted, that after transition time T' the velocity u'_{ES} between any two points E and S is constant, as the related avol ε'_0 and ε' are constant.

The resulting velocities in the system of point E are given by following relativistic addition of velocities

$$u_x = \frac{(u'_x - v)}{(1 - u'_x \cdot v/c^2)}$$

$$u_y = u'_y \cdot \frac{\sqrt{(1 - v^2/c^2}}{(1 - u'_x \cdot v/c^2)}$$

with ε'_0 being the avol of point E ($v = c - \varepsilon'_0$) we obtain with high accuracy

$$u_x = \frac{c\cdot(\varepsilon'_0 - \varepsilon'_x)}{(\varepsilon'_0 + \varepsilon'_x)} \tag{7a}$$

$$u_y = 2c\,\frac{\sqrt{(\varepsilon'_x - \varepsilon')\cdot\varepsilon'_0}}{(\varepsilon'_0 + \varepsilon'_x)} \tag{7b}$$

resulting in following velocity u between E and S

$$u = c \cdot \sqrt{\frac{1-(4\varepsilon' \cdot \varepsilon_0')}{(\varepsilon'_0 + \varepsilon'_x)^2}} \tag{7c}$$

As the Lorentz transformation is linear, any linear relation between r', u' and t' in the system of point U transforms also into a linear relation in the system of the earth. Therefore if the velocity between two points does not depend on time in one system its the same in the other system. This means, that the velocities of stars in the system of the earth are also constant in time from the transition time T' onward up to today.

Above equation (7) describe the Lorentz transformation of the constant velocity u' of any point S from the system of point U into the constant velocity u between the point E and S in the system of the earth. Consequently at a time T, still very big compared to the transition time T', the distance D between the earth and point S is given by

$$D = u \cdot T \tag{8}$$

The set of all points S in the system of point E is given by the transformation of the set of all points S in the system of point U, taking their actual avol values ε' und $ε'_x$. The actual values of ε' und $ε'_x$ depend on above mentioned variation parameter L and the distribution function f(ε‘) in relation to the avol $ε_0$’ of the earth.The picture of this transformation in the system of point E represents the universe as observed from it. Fig. 3 shows a schematic diagram thereof

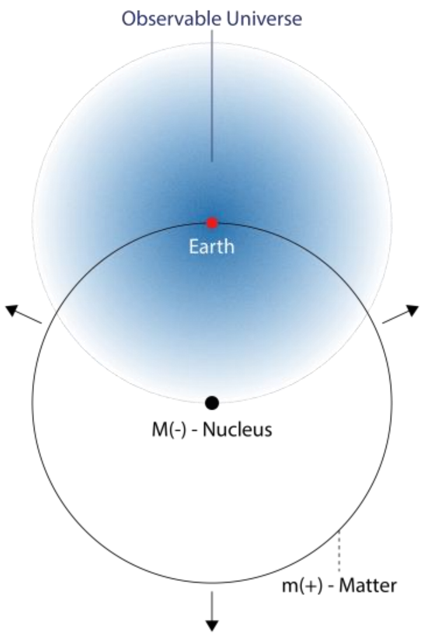

Fig. 3 Scheme of the observable universe
In the system of point U (“M(-)-Nucleus”) the earth is a point E in the expanding thin m(+)shell of the cosmos. However, in the system of point E the velocities of other points in this m(+) shell to it have to be computed by relativistic addition of velocities. Through this transformation the distances of other points as observed at point E are blown up. Next, the more distant a point the higher its escape velocity from point E. The resulting observable universe is given by the blue colored area in this diagram.

Fig. 4 shows a more detailed example of such transformation with a distribution parameter of L = ± 1 and a constant density distribution between these limits.

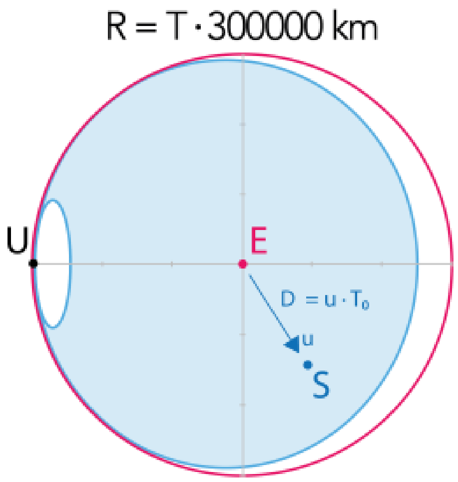

Fig.4 The observable universe
This figure shows an example of the observable universe as seen from point E (avol ε_0'). The observable universe is made up of all other points, whose avol ε' fulfills the condition:

$$\varepsilon_0' \cdot 10^{-1} < \varepsilon' < \varepsilon_0' \cdot 10^{1}$$

The horizontal line U-E is defined as x-axis, the line perpendicular to it as y-axis. The plane given by the x- and y-axis contains point S ("Star"). As the velocities u_x and u_y are constant, today's distance D of the star S to the earth E is given by $u\,T_0$ with T_0 as the time passed since the Big Bang and $T_0 \gg T'$, the transition time T'. The red circle is the maximum distance of $13{,}8 \cdot 10^9$ light years to earth. The density has rotational symmetry to the x-axis.

Even though the shape of the observable universe depends strongly on the variation parameter L and the density distribution f(ε) following basic conclusions can already be drawn.

The hypothetical savant at our point E discovers an universe, which indeed closely resembles what the astronomers on earth actually observe. Transforming the velocities u' of mass points S from the point U system to his own this savant will identify mass points expanding from him in all directions with velocities u ranging from zero up to nearly light speed. He will find out that all other points are expanding from him, the farer in distance the higher the observed expansion velocity u.

The savant at point E knows, that this amazing picture of the observable universe has been created through the relativistic addition of velocities to his own system. In contrast, an actual observer on earth will explain the observed expansion of all stars from earth only by an expansion of space, as he can not recognize any causing force.

As further consequence the savant will discover that the matter is not isotropicly distributed around him but rather flat , with a rotational symmetry around his chosen x-axis.

Points in the x-axis stay in the x-axis after transformation. The same holds true for points in the plane perpendicular to the x-axis containing point S in the x-y plane.

As the point E is not a special place in the m(+) shell a savant at any other point E' in the m(+) shell would make the same conclusions about his universe. This aspect can be considered as a verification of the cosmological principle in this model. Strictly speaking this applies only for points E' having the same distance R' to point U as point E. For gradually changing distances R' +ΔR' the observed distribution of matter will gradually change.

However, following attention has to be paid: It is evident that the properties of the observable universe near point E can and will be modified or disturbed by a combination of later occurring gravitational, nuclear and electromagnetic interactions. These disturbances could be caused by the non-isotropic distribution of matter and can consist in the generation or annihilation of stars, black holes and galaxies. In particular in the vicinity of point E, where the velocities originated by the Big Bang are low, the later disturbances will dominate and completely screen the original velocity pattern. Therefore it should be kept in mind that the conclusions of the present model are only applicable where the later disturbances play a minor role. This applies more likely for more distant stars with higher original velocities. Anyhow, the author wishes to clarify, that these later disturbances are not taken account of in the following.

If the velocity u from a point S („star") can be determined then today's distance D can be calculated by the relation (8) with high accuracy

$$D = u \cdot T_0 \qquad (9)$$

with T_0 being the time of $13{,}8 \cdot 10^9$ years after the Big Bang and the transition time T' very small compared to T_0 , see above equation (6).

Based on above, the red shift z of light observed on earth from distant stars can be fully explained by the Doppler shift . The red shift of the Doppler effect is given by

$$z = \sqrt{\frac{(1+u/c)}{(1-u/c)}} - 1 \qquad (10)$$

Combining equations (9) and (10) leads to the fundamental relation of the observable universe resulting from the new dual cosmos model (in the following called basic relation)

$$D = \frac{u \cdot T_0}{\sqrt{(c+u)/(c-u)} - 1} \cdot z \quad \text{(Lj)} \qquad (11)$$

With the following definitions:

D = todays distance of a star S from the earth
u = escape velocity (expansion velocity) of this star S from earth
z = red shift of light from this star S, as determined on earth
T_0= time passed since the Big Bang

Using this basic relation the distance of stars can be calculated, if the time passed since the Big Bang is known. Alternatively, if by other cosmic observations the distance of a star is known, the age of the cosmos can be determined. The basic relation applies as long as the impact on velocities by later acting exchange forces and/or gravitational forces are negligible (see above remark). Fig. 5 shows the distance D of a star as a function of the red shift of light from this star as observed on earth taking T_0 as $13{,}8 \cdot 10^9$ light years.

According equation (11) the entity D/z depends in today's time T_0 only on the velocity u. Therefore D/z may be replaced by a function B(u)

$$B(u) = \frac{u \cdot T_0}{\sqrt{(c+u)/(c-u)} - 1}$$

The function B(u) is rather constant for smaller velocities u of up to about 40000 km/s, where it can be approximated by

$$\lim_{u \to 0} B(u) = B(0) = \lim_{u \to 0} \frac{u \cdot T_0}{\sqrt{(c+u)/(c-u)} - 1} = T_0 \cdot c$$

As surprising result the limit value B(0) corresponds mathematically to the Hubble constant H_0

$$H_0 = c/B(0) \qquad (12)$$

This astonishing match, at least for distances of about $2 \cdot 10^9$ light years, shows that the model of the Dual Cosmos generates the same result as the standard model and within above limit supplies a description of the cosmos at least as good as the standard model. However, the underlying conditions of the two models are completely different. In the standard model the distance D between stars has been created by the expansion of the space, whereas in the present model the increasing distance D between the matter (and lateron the stars) results from the expansion of the matter caused by the repulsive force of the M(-) nucleus. The constant expansion velocities are transformed by the relativistic addition into the inertial system of the earth, generating the observable universe governed by equation (11).

As shown in Fig. 5 in the present model of the cosmos shows no proportional relationship between the distance of stars and the red shift z of light from these stars as measured on earth. The red shift z is changing overproportionally with distance.

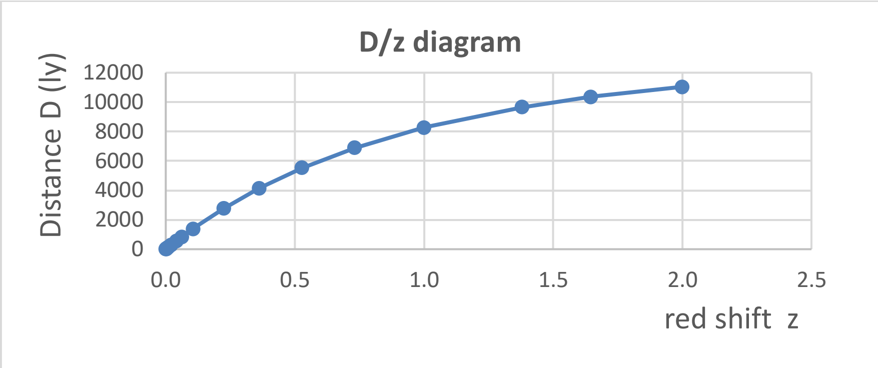

Fig. 5 Distance of stars vs. red shift

Despite the different interpretation of the Hubble parameter in this research project, we still keep the term Hubble parameter as it stands for the increasing distance of stars from the earth with increasing red shift. With the help of the basic relation (11) the Hubble parameter

$$H = c \cdot z / D (km \cdot s^{-1} \cdot Mpc^{-1})$$

Is given as function of velocity u or distance D (using $D = u \cdot T_0$)

$$H = c \cdot (\sqrt{(c+u)/(c-u)} - 1) / (u \cdot T_0) \quad \text{or} \qquad (13a)$$

$$H = c \cdot (\sqrt{(cT_0 + D)/(cT_0 - D)} - 1) / D \qquad (13b)$$

The corresponding variation of the Hubble parameter is shown in Fig.6. The good match with observations indicates the correctness of the model. However, it should again be noted, that here the derivation and interpretation of the Hubble parameter is completely different to the standard model. The dramatic advantage of the new derivation is the abolition of the hypothesis of expansion of the (empty) space including the related unsolved problems, e. g. the loss of energy of light during the assumed “cosmic red shift”. Here the loss of energy of light is explained by the well known relativistic Doppler effect.

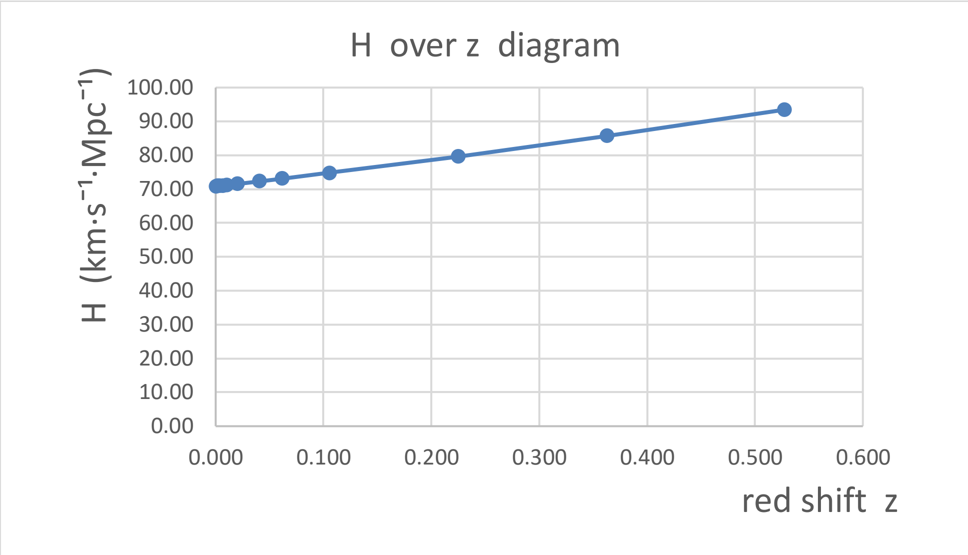

Fig.6 The Hubble parameter *The Hubble parameter can be defined as H = $c \cdot z/D$ (km·s $^{-1}$·Mpc^{-1}). Fig. 6 shows the variation of this parameter with the red shift z in the model of this work*

In the present dual cosmos model there exists a proportional relationship between distance and velocity, whereas the red shift z increases overproportionally with distance and velocity. In the standard model the expansion rate increases overproportional with distance, as long as the distance is taken as proportional to the red shift z. The data obtained by analysis of light from the cepheids could be helpful to decide between the two approaches. The distances D as calculated by the Doppler red shift z of light from the cepheids with the help of above base function (11) shall be the same as the well known distances of cepheids by other cosmological data.

Above is a summary of the main physical reasoning and deduction of the dual cosmos model. Its basic results are achieved without violation of the energy conservation principle and without the hypothesis of expansion of the (empty) space. Nevertheless its results, e.g. cosmological principle, existence of a Big Bang, relation between distance and velocity of stars match the observations of the cosmos. Further more detailed results of this dual cosmos model with respect to

- the rotational symmetry of the matter distribution in the observable universe

- the ratios of total forces: attraction on normal matter to attraction on dark matter to repulsion on normal and dark matter ("effect of dark energy") can be calculated as

  -5.13 to -28.2 to +66.7

  These ratios are identical to the ratios of potential energies, i.e. the energy reservoir from today's cosmos until the end of expansion

- Explanation of the background radiation, though there is quantitative discrepancy from the standard model

are published elsewhere[1)].

Summarizing , besides the inherent beauty of the dual cosmos model, containing no mathematical extravagancies and being in accordance with all physical principles valid on earth, this model seems to be a proper tool to describe the properties of the cosmos stemming from the Big Bang. The author hopes, that the validity of this model could be substantiated by further discussion in the worldwide web and by detailed comparison with cosmological data

1) O. Beer. Dunkle Energie und Kosmos (2019) Cuvillier Verlag Göttingen