Part 7: Redshift

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The aim we are pursuing in this part of our discussion is to go on analysing the redshift of highly intensive gravitational waves [1].

The reasons why we have been involved in this overall reviewing it, are the following:

1. more gravitational waves have, in the meantime, reached the detector (particularly in 2001 and 2002);
2. the evaluation of wave intensity has been improved by the using the amplitude of its "rebounding" too ;
3. the intensity of the first waves detected by our detector (in 1994) should be cautiously considered, as the photoresistor had no "formatting" and the instrument was not yet well set up;
4. in September 2002, a rather "clean" "fork" was detected, which as been used as *reference wave*.

However, before going on with the analysis, it is useful to remark a few things about the propagating of gravitational waves.

1 Propagation of a gravitational wave

In **Figure 1** the propagation of a gravitational wave of high intensity caused by the collapsing of a Multiple Nucleus Quasar (QNM), is schematically represented.

Characteristics of these waves can be indicated as follows.

1. *The gravitational wave is a density wave* (of the "physical" space) which propagates with a *speed which is inversely proportional to the cubic root of its density.* Namely:

$$c_0 = c_\infty \left(\frac{\delta_\infty}{\delta_0}\right)^{1/3} \tag{1}$$

[1] See Appendix of **A detector for Gravitational Waves:** *Multiple Nucleus Quasar.*.

where, pedex "$_0$" indicates the "local" values, while pedex "$_\infty$" the ones concerning space at "rest" (that is to say with no fields) [2].

It is possible to write (1) also in the following way:

$$\delta_0 \; {c_0}^3 = \delta_\infty \; {c_\infty}^3 = constant \tag{2}$$

2. *The bodies plunged in a gravitational field, change their dimensions in direct proportion to the changes of the speed of light of the place they are.*

   For example, a body which volume at "rest" is V_∞ plunged into a gravitational field, where the speed of light is c_0 undergoes a decrease of its volume by:

$$V_0 = V_\infty \; \frac{{c_0}^3}{{c_\infty}^3} \tag{3}$$

   If we use (2), we obtain:

$$\delta_0 \; V_0 = \delta_\infty \; V_\infty \equiv mass \; of \;\; space = constant \tag{4}$$

   Therefore, *the mass of space into the considered volume does not vary.*

   In other words, we can say that *in a volume which vary "according to the speed of light" the mass of space (and matter too!) included therein is always the same* [3].

3. Intensity I of a gravitational wave, is directly proportional to the changes of the speed of light [4]:

$$I \propto \delta_\infty \; {c_\infty}^3 \; \frac{c - c_0}{c_0} \tag{5}$$

   therefore, *the intensity of a gravitational wave results as directly proportional to amplitude A, in Volts, of the signal coming from the detector.*

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[2]We remind that the values of space "at rest" are the following:

$$\delta_\infty = 3 \; 10^{17} \; kg/m^3$$

$$c_\infty = 3 \; 10^8 \; m/s$$

therefore, (universal!) constant (2) takes the following value:

$$constant \equiv \delta_\infty \; {c_\infty}^3 = 3 \; 10^{17} \; \left(3 \; 10^8\right)^3 = 8.1 \; 10^{42} \; kg/s^3$$

[3]An *internal observer*, who is "plunged" into the same gravitational field, *cannot notice that the dimensions have changed*, and cannot notice that both speed of light and density have changed as well.

Our CdS detector, on the contrary, behaves like an *external observer*!

[4]We can say that this peculiarity is directly resulting from the properties represented by (2). See **Appendix** where you can find the corresponding proof.

4. *“Physical” space does not undergo any loss of energy*, therefore, the (gravitational) energy of a wave, while propagating, keeps constant (also in case of very far distances). Therefore, energy $\dot{U}$ carried per unit of time by a wave results as corresponding to:

$$\dot{U} = 4\ \pi\ r^2\ I \approx constant \tag{6}$$

2 Redshift

Distance r of the place where collapsing of a nucleus occurred and width T of the corresponding wave must be corrected for *redshift* z due to the expanding of Universe [5]. Namely we have:

$$\left(r\right)_{z=0} \equiv r_0 = \frac{r}{z+1} \tag{7}$$

$$\left(T\right)_{z=0} \equiv T_0 = \frac{T}{z+1} \tag{8}$$

Let us consider two collapses that we are indicating with pedex “$_1$” and pedex “$_2$“), that happened in different places of the Universe. We are going to see that, in the hypothesis that the two events had *the same energetic intensity*, it is possible to calculate *both* redshifts, starting from the ratio between either amplitude A and the corresponding width T of the respective “fork”. We can write:

$$\frac{{r_2}^2}{{r_1}^2}\ \frac{A_2}{A_1} \equiv \frac{{R_U}^2\ {z_2}^2\ \left(z_1+1\right)^2}{{R_U}^2\ {z_1}^2\ \left(z_2+1\right)^2} \frac{A_2}{A_1} = 1 \tag{9}$$

where for distances r_1 e r_2 the previous equation (7) has been used. If we indicate:

$$A_{ratio} = \frac{A_2}{A_1}$$

$$w_{ratio} = \frac{w_2}{w_1} \equiv \frac{z_2+1}{z_1+1}$$

we can obtain the following system of two equations having the two unknown quantities z_1 e z_2:

$$w_{ratio} = \frac{z_2}{z_1}\ \sqrt{A_{ratio}} \tag{10}$$

$$w_{ratio} = \frac{z_2+1}{z_1+1} \tag{11}$$

[5] See in this respect, what referred in **Matter and Universe:** *The expansion of Universe.*

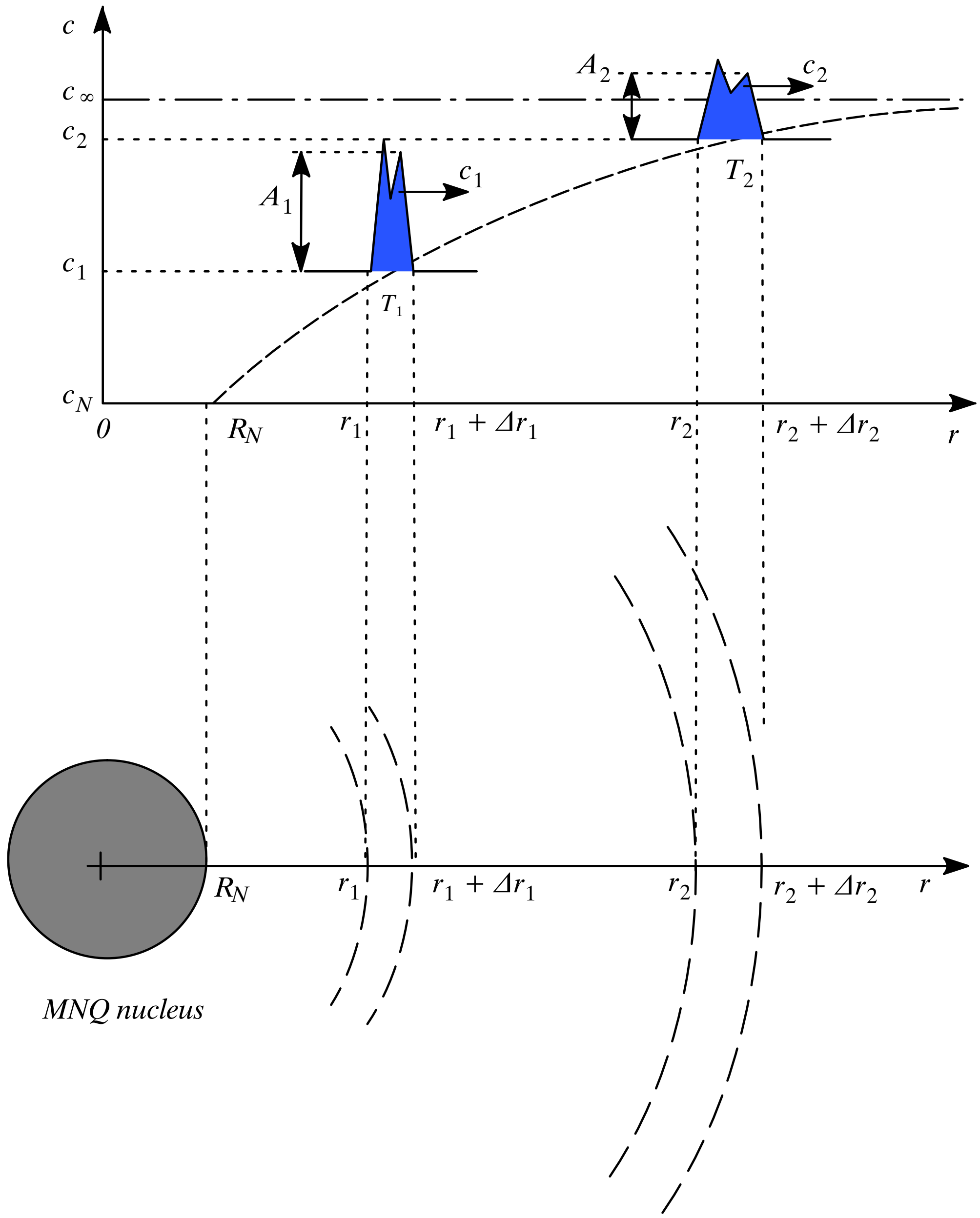

Figure 1: Propagation of a gravitational wave

according to which we can obtain z_1 and z_2:

$$z_1 = \frac{\sqrt{A_{ratio}}}{w_{ratio1}} \, \frac{w_{ratio} - 1}{1 - \sqrt{A_{ratio}}} \tag{12}$$

$$z_2 = \frac{w_{ratio} - 1}{1 - \sqrt{A_{ratio}}} \tag{13}$$

In case there are several waves the steps to do are the following. If we replace (12) and (13) with (10) the following relation between amplitude and widening of the wave can be obtained:

$$\frac{1}{\sqrt{A_{ratio}}} = \frac{1}{w_{ref} - 1} \left(w_{ref} - \frac{1}{w_{ratio}} \right) \tag{14}$$

where, the following has been indicated:

$$A_{ratio} = \frac{A}{A_{ref}}$$

$$w_{ratio} = \frac{T}{T_{ref}}$$

where, A_{ref} and w_{ref} are, respectively, the amplitude and the widening of the *reference wave*.

For each wave we can report on a graph the value of $1/\sqrt{A_{ratio}}$ as function of $1/w_{ratio}$. If all collapses had the same energetic intensity, *the points thus calculated should lay on the same straight line*, with negative slope, which intersection with the axis of the abscisses will directly allows to obtain the widening w_{ref} of the reference wave.

Once the redshift w_{ref} is stated, the redshift of the other waves can be calculated using the following equation:

$$z = w_{ratio} \, w_{ref} - 1 \tag{15}$$

which can be also used to obtain the other parameters. Namely:

- the distance r_0 of the nucleus at the moment of collapsing:

  $$r_0 = R_U \, \frac{z}{z + 1} \tag{16}$$

  where, R_U is the *radius of the visible Universe*, which is related to Hubble constant H_0 and to the speed of light c by the following relation:

  $$R_U = \frac{c}{H_0} \tag{17}$$

- the travelling time Δt of the gravitational wave to reach the detector:

$$\Delta t = t_H \ \ln(z+1) \tag{18}$$

where, t_H is the *Hubble time* defined as follows:

$$t_H = \frac{R_U}{c} \tag{19}$$

- the distance r from the place of collapsing, at the moment when the wave reaches the detector:

$$r = r_0 \ \big(z+1\big) \tag{20}$$

2.1 The waves considered in our survey

Ratio w_{ratio} between widening is also equal to the ratio of distance T between the "fork" peaks, therefore it is possible to calculate it quite exactly.

It is, however, more difficult to calculate ratio A_{ratio} of the amplitudes, above all, because of overlapping of the various waves reaching the detector. It is, therefore, possible to calculate it rather precisely only if the wave results to be isolated.

In this new analysis, further than the average amplitude $\hat{A} = (A_1 + A_2)/2$ of the "fork" peaks, also the average amplitude $\check{A} = (A_3 + A_4)/2$ of the "rebounding" have been considered, as this too is *meaningful to indicate the intensity of the collapse*. Furthermore, in this evaluation, also ratio $\hat{A}/\check{A}$, which should keep quite constant, has been considered.

We are going to give, hereunder, a short description of the waves which were selected for the present analysis, while **Table 1** shows the corresponding values.

Waves N. 1, 2 and 3 These belong to the series of both positive and negative "forks", recorded by the detector between May and June 1994 (see **Graph 1994_F1**).

We have to use these waves very cautiously, as the detector "formatting" was not completed yet and the instrument was not yet well set up.

Wave N. 4 It is the big "fork" recorded between September and October 1994 (see **Graph 1994_F2**).

For these wave too, we have to take into consideration what previously stated.

Waves N. 5 and 6 These concern the two, partially overlapping, "forks" recorded between July and September 1995 (see **Graph 1995_F1**).

The partial overlapping of these waves creates some uncertainties, especially in the evaluation of the amplitude of the rebounding.

Waves N. 7 e 8 These concern the "forks" recorded between July and August 1998 (see **Graph 1998_F1**).

The uprising front of the first wave and the primary peak show are disturbed by a sudden lowering of the underlying signal. Therefore, the amplitude of the peak is more likely represented only by the amplitude of the secondary peak $\hat{A}_1 = 0.40\ V$ without taking account of the primary peak.

In the second wave, on the contrary, the rebounding only is well visible.

Wave N. 9 This is the "fork" recorded in September 1998 (see **Graph 1998_F2**).

This wave shows rather "clean". Only slight oscillations can be seen, probably due to variations of the sensor temperature.

Waves N. 10 e 11 These waves show a positive and a negative "fork" recorded between January and March 1999 (see **Graph 1999_F1**).

The secondary peak of the negative "fork" and the primary one of the positive "fork" result as overlapped, therefore they could not be taken into account.

Wave N. 12 It is the first "fork" recorded in July 1999 (see **Graph 1999_F2**).

The amplitude of the secondary peak of this wave could not be considered, as the sloping down results as being very disturbed.

Wave N. 13 This is the high intensity "fork" recorded from the middle of August 1999 (see **Graph 1999_F4**).

The uprising front results being disturbed by the secondary peak of the previous collapse which had not yet extinguished, while the sloping down is partially "cut" by the oncoming of the second wave which reached the detector on the 24th August. Therefore, it seems more reasonable to consider for the amplitude of this wave solely the secondary peak ($\hat{A}_1 = 0.80\ V$) and leave off considering the primary one.

Wave N. 14 It is the case of a "fork" recorded in August 2001 where only the rebounding can be seen (see **Graph 2001_F1**).

Wave N. 15 This "fork" was recorded between September and October 2002 (see **Graph 2002_F1**).

The uprising front of the wave cannot be seen, while the other portion seems rather "clean".

2.2 Reference wave

Being unable to consider the "fork" of September/October 1994 (**Onda N. 4**) because of the reasons above mentioned we indicate, hereunder, other "cleaner" waves which are the following:

Table 1: Values concerning the selected waves

$Wave$ N.	T $days$	A_1 $Volts$	A_2 $Volts$	$\hat{A}$ $Volts$	A_3 $Volts$	A_4 $Volts$	$\check{A}$ $Volts$	$\hat{A}/\check{A}$ -
1	4.0	0.66	0.83	0.745	0.26	0.30	0.28	2.66
2	4.0	0.80	-	0.80	0.36	0.33	0.345	2.32
3	4.0	-	-	-	0.37	0.40	0.385	-
4	7.5	2.4	2.1	2.25	0.71	0.92	0.815	2.76
5	15.0	0.23	-	0.05	0.11	0.08	0.11	2.88
6	17.0	-	0.24	0.15	0.09	0.12	0.13	2.00
7	4.5	0.40	-	0.40	-	0.15	0.15	2.67
8	4.5	-	-	-	0.12	0.20	0.16	-
9	6.5	0.34	0.32	0.33	0.11	0.11	0.11	3.00
10	13.0	0.22	-	0.22	0.11	0.08	0.095	2.32
11	12.0	-	0.17	0.17	-	0.10	0.10	1.70
12	7.0	0.32	-	0.32	0.12	0.10	0.11	2.91
13	2.5	0.80	-	0.80	0.26	-	0.26	3.08
14	11.4	-	-	-	0.14	0.15	0.145	-
15	11.5	-	0.35	0.35	0.16	0.17	0.165	2.12

- **Wave N. 8** of September 1998
- **Wave N. 12** of August 1999
- **Wave N. 14** of September 2002

We have used in our analysis all three waves but, in the end, as reference wave we have chosen the one of September 2002. Namely:

$$\hat{A}_{ref} = 0.35\ Volts$$

$$\check{A}_{ref} = 0.165\ Volts$$

$$T_{ref} = 11.5\ days$$

as it produced a lower dispersion of data (respect to the straight line). In **Table2** all data thus obtained are indicated.

In graph of **Figure 2** the pairs of values $(1/w_{ratio}, 1/\sqrt{A_{ratio}})$ are reported. The graph shows how all waves but the ones of 1994 are, very likely, situated in a straight line intersecting the axis of the abscisses at point:

$$w \equiv w_{ref} = 9.5$$

Table 3lists the parameters concerning the considered waves thus obtained. [6].

[6]For calculations the following value for the Hubble constant have been considered:

$$H_0 = 25\ km/s\ per\ million\ of\ light-years$$

Table 2: Data for redshift analysis.

$Wave$ N.	$\hat{A}_{ratio}$	$\check{A}_{ratio}$	w_{ratio}	$1/\sqrt{\hat{A}_{ratio}}$	$1/\sqrt{\check{A}_{ratio}}$	$1/w_{ratio}$
	-	-	-	-	-	-
1	2.139	1.697	0.35	0.69	0.77	2.88
2	2.286	2.091	0.35	0.66	0.69	2.88
3	-	2.333	0.35	-	0.65	2.88
4	6.429	4.939	0.65	0.39	0.45	1.53
5	0.657	0.485	1.30	1.23	1.44	0.77
6	0.686	0.727	1.48	1.21	1.17	0.68
7	1.143	0.909	0.39	0.94	1.05	2.56
8	-	0.970	0.39	-	1.02	2.56
9	0.943	0.667	0.57	1.03	1.22	1.77
10	0.629	0.576	1.13	1.26	1.32	0.88
11	0.486	0.606	1.04	1.43	1.28	0.96
12	0.914	0.667	0.61	1.05	1.22	1.64
13	2.286	1.576	0.22	0.66	0.80	4.60
14	-	0.879	0.99	-	1.07	1.01
15	1.00	1.00	1.00	1.00	1.00	1.00

Table 3: Parameters concerning the selected waves.

$Wave$ N.	w -	z -	T_0 $days$	r_0 $\times 10^9$ $l.y.$	r $\times 10^9$ $l.y.$	Δt $\times 10^9$ $years$
1	3.3	2.3	1.2	8.4	27.7	14.3
2	3.3	2.3	1.2	8.4	27.7	14.3
3	3.3	2.3	1.2	8.4	27.7	14.3
4	6.2	5.2	1.2	10.1	62.3	21.9
5	12.4	11.4	1.2	11.0	136.7	30.2
6	14.0	13.0	1.2	11.1	156.5	31.7
7	3.7	2.7	1.2	8.8	32.6	15.8
8	3.7	2.7	1.2	8.8	32.6	15.8
9	5.4	4.4	1.2	9.8	52.4	20.2
10	10.7	9.7	1.2	10.9	116.9	28.5
11	9.9	8.9	1.2	10.8	107.0	27.5
12	5.8	4.8	1.2	9.9	57.4	21.1
13	2.1	1.1	1.2	6.2	12.8	8.7
14	9.4	8.4	1.2	10.7	101.0	26.9
15	9.5	8.5	1.2	10.7	102.0	27.0

therefore, as *radius of the visible Universe* the following value is obtained:

$$R_U = \frac{c}{H_0} = \frac{300,000}{25}\ 10^6 = 12\ billionlight - years$$

The *real* distance between the "fork" peaks, results as being of 1.2 days. Uprising time of the wave, which is strictly related to the nucleus radius, is of the same order of magnitude. Therefore, the *real* radius R_N of the nucleus results as:

$$R_N \approx 1.2 \; light - days$$

where the speed of light is the "local" one, still unknown to us [7].

The *appearing* radius of the nucleus, that is to say as *seen by an observer placed outside to the gravitational field*, on the contrary results as follows:

$$\left(R_N\right)_\infty \approx 1.2 \; 86,400 \; 300,000 = 31 \; 10^9 \; km$$

The mass of space collapsing with the nucleus, because of (2), results as easy to calculate:

$$\frac{4}{3}\,\pi\,\left(31 \; 10^{12}\right)^3 \; 3 \; 10^{17} = 1.9 \; 10^{28} \; M_\odot$$

As we can see, *this mass is larger than the mass of matter forming the Universe*!

3 Remarks

1. By using also the "rebounds" a remarkable improvement of the precision of redshift calculations has been obtained.

2. If compared with the previous analysis, the wave redshift and, therefore, the distances of the collapsed nuclei have increased. Specifically, due to the recordings up to now (August 1999), the two collapses the nearest to us, are now placed at distance practically twice as far, if compared with the previous data.

3. This analysis, shows evidence that gravitational waves may cover very long distances without remarkable energy loss and without undergoing meaningful distortions. The only effect resulting is due to the lowering/widening due to redshift.

4. It is with surprise that we can remark how this detector succeeds in "seeing" so well even the waves with very high redshift ($z > 10$), which were generated by events happened in the far boundaries of the visible Universe!

[7] We are going to see better, later on, how it is possible from the wave "dimensions" to calculate the speed of light on the nucleus surface. It is a very low speed, in the order of one meter per second!

4 Conclusion

The analysis of the redshift as presented here takes account of our recordings from 1994 to December 2002, even if we need to be cautious in dealing with the first recordings.

We will gradually update the present analysis, as long as other waves are recorded by our detector and new collapses of QNM are detected.

It is worth to notice that the presence of redshift inside these waves, represents most convincing evidence that what our detector is recording exactly *Gravitational Waves*.

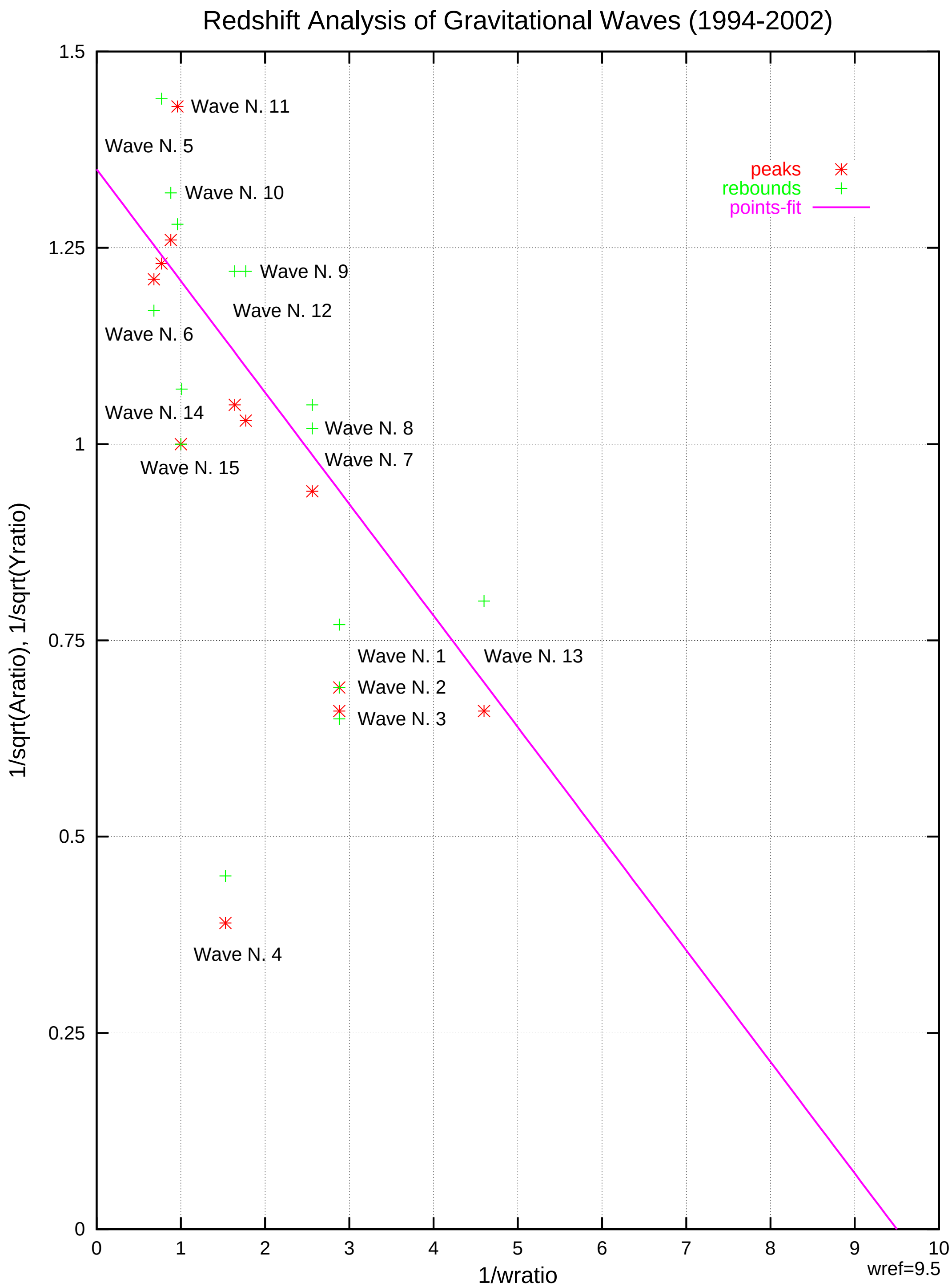

Figure 2: Redshift analysis (ref. **Wave N. 14**)

A APPENDIX

A.1 Properties of the “physical“ space

It is well known that relationship between the speed of propagation and the physical properties (pressure p and density δ) of the medium is represented by the following equation:

$$\frac{dp}{d\delta} = c^2 \tag{21}$$

For a gravitational wave, keeping in mind that propagation speed, c, is related to space density by (1), we obtain:

$$\frac{dp}{d\delta} = {c_\infty}^2 \left(\frac{\delta_\infty}{\delta}\right)^{2/3} \tag{22}$$

which, when integrated gives the following result [8]:

$$p - p_0 = 3\ \delta_\infty\ {c_\infty}^2 \left[\left(\frac{\delta}{\delta_\infty}\right)^{1/3} - \left(\frac{\delta_0}{\delta_\infty}\right)^{1/3}\right] \tag{23}$$

(23) can be also expressed as function of the speed, c. If we use (1) we can, in fact, obtain:

$$p - p_0 = 3\ \delta_\infty\ {c_\infty}^3 \left(\frac{1}{c} - \frac{1}{c_0}\right) \equiv 3\ \delta_0\ {c_0}^2\ \frac{c_0 - c}{c} \tag{24}$$

which links, directely, the *eccess of pressure*, $p - p_0$, with the propagation speed, c.

A.2 Density of energy of a gravitational wave

The (gravitational) energy equals the *work done to compress the “physical” space*. Therefore, the density of energy, u, of a gravitational wave can be expressed as *proportional to the excess of pressure* respect to the indisturbed space. Namely:

$$u \propto p - p_0 \propto\ \delta_0\ {c_0}^2\ \frac{c_0 - c}{c} \tag{25}$$

[8](23) can be considered as a sort of *state equation for the space*, where (at the moment) *temperature still results as missing.*

In the future, we will see how it is possible to consider this quantity too in measuring the *Background Cosmic Radiation* (CMB), which may provide exact indications about the amount of matter existing in the Universe.

A.3 Intensity of a gravitational wave

The intensity, I, of a wave, is related to its density of energy, u, by:

$$I = u\ c \tag{26}$$

Therefore, by using (25) into (26), for a gravitational wave we have:

$$I \propto \delta_0\ {c_0}^2\ \big(c_0 - c\big) \equiv \delta_0\ {c_0}^3\ \frac{c_0 - c}{c_0} = \delta_\infty\ {c_\infty}^3\ \frac{c_0 - c}{c_0} \tag{27}$$