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THE GRAVITATIONAL VOICE

number 31

July 2016

new events ... and more to come!!

News from EGO and VIRGO

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"h - The Gravitational Voice" is an internal publication of the European Gravitational Observatory (EGO) and the Virgo Collaboration.

The content of this newsletter does not necessarily represent the opinion of the management.

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Published in electronic format on the EGO Web:
www.ego-gw.it

Cover Page:
The figures show the sky locations of the first and second gravitational wave detection events (GW150914, GW151226) and of the candidate event LVT151012 (see A. Vicere' s article). Left figure shows the locations obtained using LIGO only signals while, on the right, a simulation of the impressive effect of VIRGO on the localization of the sources is presented.

EDITORIAL

After the special h "discovery issue" announcing and celebrating the first detected gravitational wave event, we go on with a "normal" issue, announcing a not-less outstanding achievement: the detection of two other events confirming clearly the detection of gravitational waves and the existence of black holes of a large mass range.
In the Virgo community there is some modesty/reticence in speaking of two new events, since one of them provides a quite weak signal. I don't share this attitude: one has simply to quote the statistical significance of each event, the weak one being a "two sigma" event, while the strong ones are of a "five sigma" quality. In other words, we can say that the corresponding probability of having false events of the same amplitude is, respectively, one event every few years and one event every few million years!

C.Bradaschia
Chief Editor

More GW Events

The first detection of gravitational waves made by LIGO detectors in September 2015, and announced to the public in February 2016, generated lots of questions, but for LIGO and Virgo folks one of them was particularly difficult to address: "did you see anything else in the data?

Is there more than GW150914" ? It was a tough question because indeed, we knew there was more. Actually, already in the GW150914 paper, which was based on a subset of O1, an attentive reader could notice another event, which was above the noise background, though not as dramatically as the "gold plated" one.

More importantly, in later data, a second event had been detected on December 26th, the so-called "Boxing Day", and labelled GW151226. Actually, in the US, it was Christmas time, but the practice is to mark events according to the UTC time, and in Greenwich Christmas was over already.

So when being asked "did you see other events in the whole of O1", we had to exercise our best "occlumency" [1] skills, because we already had very good confidence in this second event.

Similarities and differences mark the two signals, though: both were due to binary black holes, and their distance, albeit estimated with large errors, is the same; at this stage, this may just be a coincidence, and for those who could speculate that the two coalescences could have occurred in the same galaxy, it is worth pointing out that the estimated locations in the sky are different, as shown in Fig.1. Yet, because of the finite propagation speed of gravitational waves, a given distance corresponds to a specific epoch, so one might be tempted to postulate processes that could cause some greater abundance of binary black holes (BBH) at some epochs of cosmic evolution; but seriously, it is too early for such speculations!

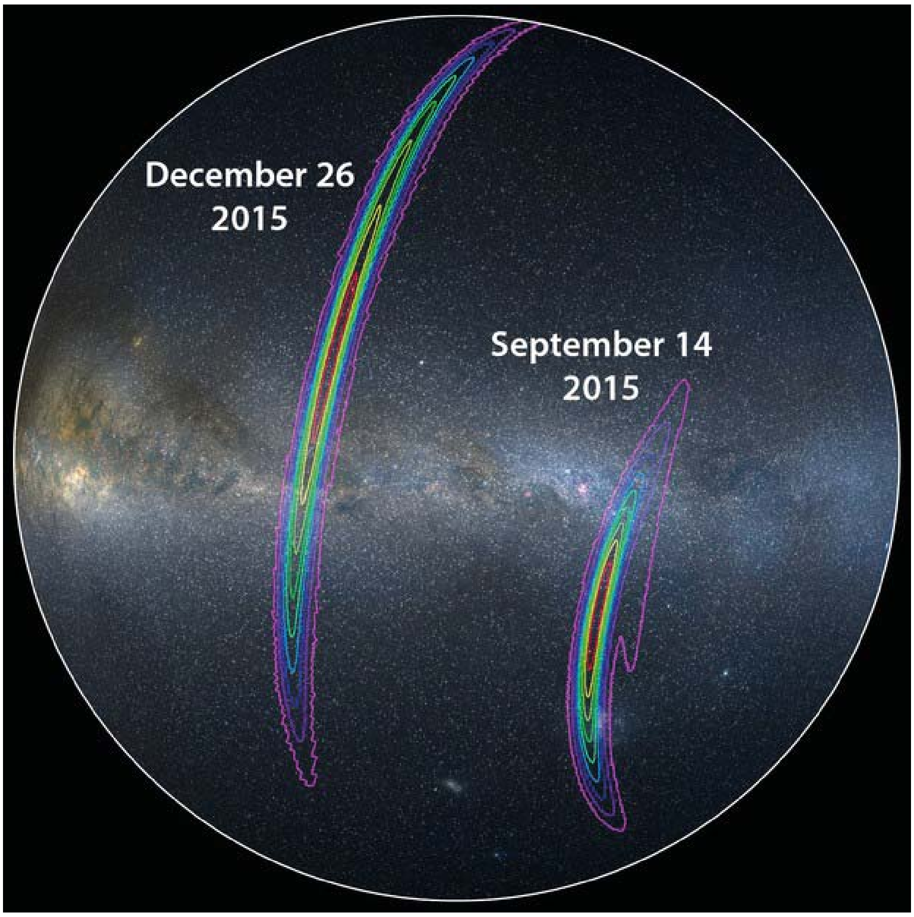

Fig. 1 : *the localisation of the two confirmed BBH detection in O1 data. The background image is a projection of the night sky, dominated by the prominent feature of the Milky Way. The contours represent the large sky areas in which the two confirmed signals have been approximately localised. Broader contours correspond to greater confidence levels that the signal was received from a location inside the contour. For instance, we are confident at a 90% level that a signal is contained in the purple, external contour, and we have a 10% confidence that it is inside the yellow, inner contour.*

The masses of the BHs in the second event (14.2 $M_\odot$ and 7.5 $M_\odot$) were more in the range of what we were expecting well before starting the O1 run for the so- called "stellar-mass black holes". We define indeed three classes of BH: the supermassive ones (SMBH) which lurk at the centre of many galaxies, with masses from hundreds of thousands to billions of solar masses, including our Milky Way, in which Sagittarius A* has an estimated mass of 4 million $M_\odot$. The intermediate-mass black holes, in a range from hundreds to hundreds of thousands $M_\odot$, whose existence is somewhat more speculative; for instance, they are thought to

[1] *http://harrypotter.wikia.com/wiki/Occlumency*

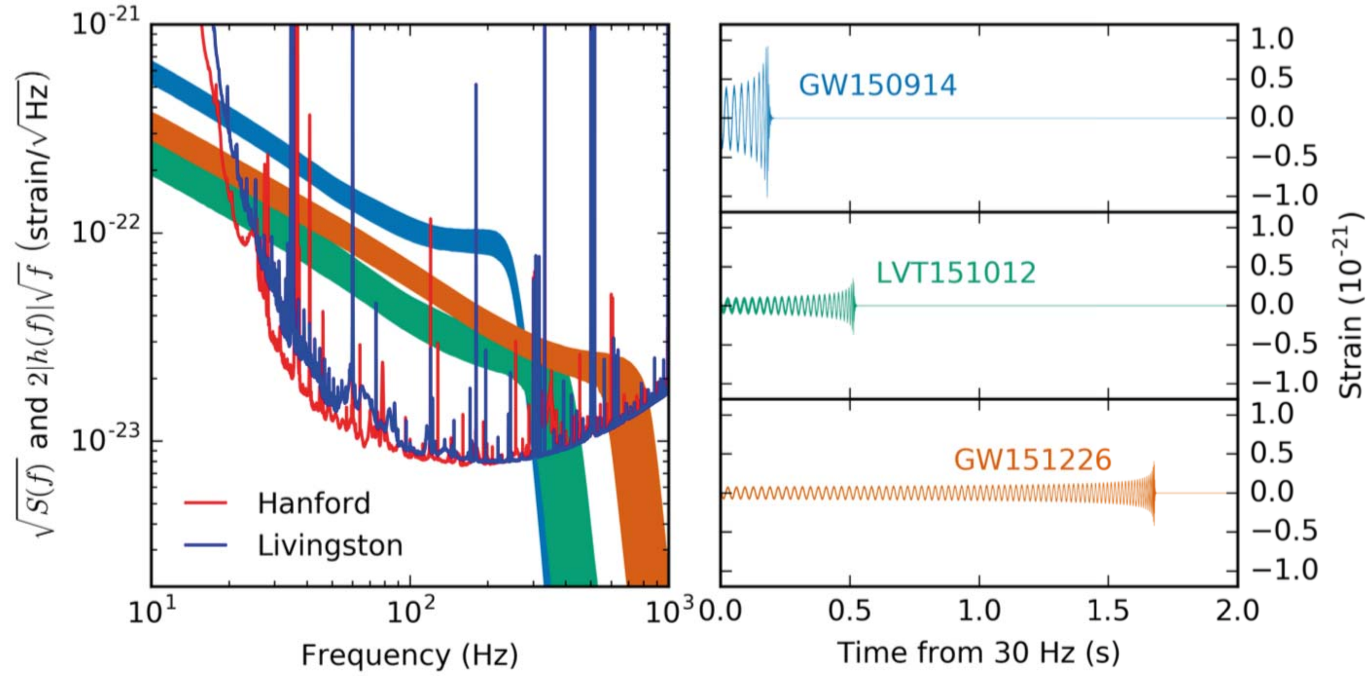

Fig 2 - *The waveforms of the confirmed detections GW150914 and GW151226, and of the candidate LVT151012. In the right panel, the reconstructed waveforms in the time domain. In the left panel, their track in the frequency domain, compared with the noise spectral density of the two LIGO detectors.*

be present in some Active Galactic Nuclei, whose activity is quite likely due to the fall of mass on an accreting BH.

And finally, the stellar-mass black holes, which by definition should originate from the collapse of a massive star; even though the formation of a BH in a collapse has never been confirmed, the observation of low-mass X-ray binaries, in which a BH is thought to be accreting mass stolen from a companion star, allows to infer the existence of objects with masses in the range 4 – 16 $M_\odot$, as observed in GW151226.

It is worth pointing out that the very occurrence of the two observed BBH mergers demonstrates that a mechanism exists through which heavier BHs can be formed; it remains to be demonstrated if this mechanism allows stellar-mass black holes to grow indefinitely, through successive mergers, and achieve the status of those of intermediate-mass.

The lower masses of the BHs involved in the second merger event resulted in another difference: the coalescence signal stayed in the detectors' band (say, above 30 Hz) significantly longer (about 1.7s instead of ~0.2s), as can be seen in Fig.2.

About 55 cycles of the signal could be observed, allowing to accumulate signal-to-noise ratio, thus compensating in part for the reduced amplitude due to the smaller masses.

Moreover, the longer signal made it possible to perform a more complete analysis and to confirm that one of the coalescing BHs of GW151226 carried a spin larger than 0.2, in units ranging from 0 (non spinning BH) to 1 (maximally spinning Kerr BH).

This is new with respect to the case of GW150914, for which we could assert that the formed BH had a spin, but we could not draw conclusions about the initial spin of the coalescing BHs, that might have been zero, in which case the final spin would have resulted just from the orbital angular momentum of the system.

Both confirmed detections have a very large significance, greater than 5.3σ, which means that O1 would have needed to have lasted millions of years to detect a false alarm, due to noise, with the same signal-to-noise ratio. However, the different duration of the signals makes them quite different from the point of view of the analysis: GW150914 could be "seen by eye", once data were frequency windowed to eliminate noise outside the signal's bandwidth.
This is not the case for the second event, which in the time domain is not conspicuous, see Fig.3. (next page).

As a consequence, GW150914 was detected online by a pipeline searching for un-modelled, burst events, whereas GW151226 was

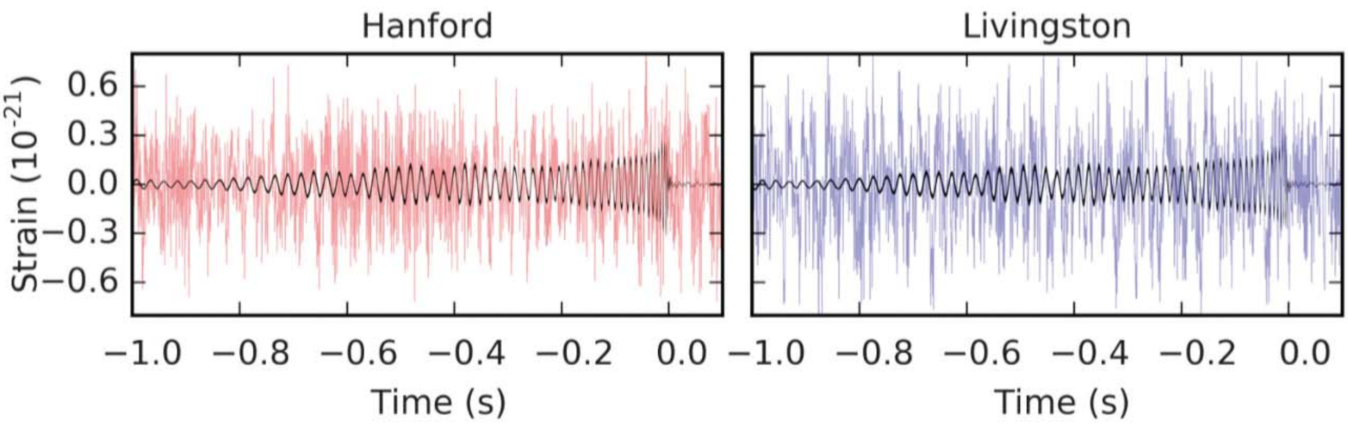

Fig 3 - *Data of the LIGO detectors containing the GW151226 event, with the reconstructed signal superposed. By naked eye, the signal would not be apparent, but the matched filter analysis identifies it with a combined SNR ~13.*

detected only by the pipeline dedicated to coalescing binaries, which exploits the predicted signal shape to extract an event from the raw data.

Incidentally, this online pipeline looking for BBH events had been activated only a few days before Christmas! Until GW150914 in fact, the modelled search was not looking online for high-mass events. There were good arguments for limiting the search to lower-mass events which could involve at least one neutron star: the presence of a NS is considered a crucial ingredient for the production, during the merger, of powerful γ-ray bursts (GRBs).

It is of paramount importance that we are able to promptly alert optical, X, γ observatories in order to possibly detect an EM-counterpart, because confirming the association between mergers and γ-ray bursts is one of the key objectives of LIGO and Virgo.

Binary black hole coalescences should not produce GRBs or more generally EM counterparts, so the urgency of an online analysis was less evident.

However, with GW150914 it was realised that a prompt analysis also allows to perform immediate cross-checks on the detectors and to acquire data in a “frozen detector” condition that greatly simplifies the statistical analysis of the event; for these reasons, the LIGO and Virgo collaboration rushed to extend the online search parameter space, covering also BBH events, and this effort was immediately rewarded with the detection of GW151226, which went instead unnoticed by the burst online analysis.

During O1 another candidate event was brought forward by the analysis groups; the so- called LVT151012, which carries however significantly less significance (< 2σ), in other words it could take years, not millions of years of observation, to observe a similar event due to noise.

Its reconstructed waveform is shown in Fig. 2 and has a duration intermediate between the two confirmed events, which corresponds to estimated mass values intermediate between the high mass of GW150914 and the lower stellar-mass values estimated for GW151226.

In my humble opinion, the limited significance of this event calls for extra care in handling any consequence, for instance in using this event for assessing the rate of mergers.

So, which conclusions could be drawn from O1? In short, binary black hole events are not particularly rare: the estimated rate is between 9 – 240 Gpc^{-3} yr^{-1}, which means that already during O2, thanks to the improved sensitivity and the presence of Virgo, it could be possible to see about ten such events.

With Virgo online, these events will be better characterised, particularly in terms of distance and sky location, and we can look forward to some very interesting physics. So, let’s get Virgo online soon!

A. Viceré

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GW151226: Observation of Gravitational Waves from a 22-Solar-Mass Binary Black Hole Coalescence, PRL 116, 241103 (2016)

[2] B. P. Abbott et al. (The LIGO Scientific Collaboration, the Virgo Collaboration), Binary Black Hole Mergers in the first Advanced LIGO Observing Run, arXiv:1606.04856 [gr-qc]

2015 GWIC and Braccini Thesis Prizes

It is a pleasure to announce that the selection committee for the GWIC Thesis Prize and the Stefano Braccini Thesis Prize has reached a decision. This year, there was a total of twenty nominated theses, from eight different countries.

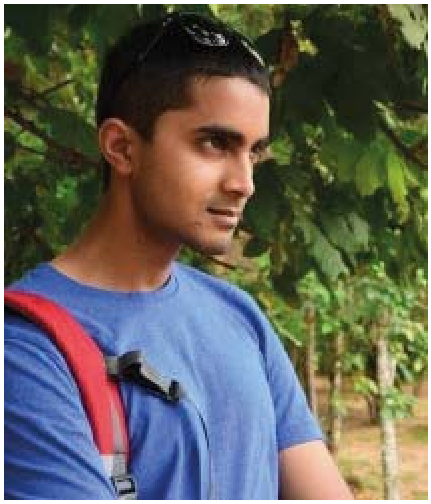
This is the third year that a single committee has selected the winners of the two thesis prizes. The selection committee was instructed to select the two best theses based on 1) originality and creativity of the research, 2) importance to the field of gravitational waves and gravitational wave detection, broadly interpreted, and 3) clarity of presentation in the thesis. To distinguish between the two prizes, the GWIC Thesis Prize emphasizes the impact on the field of gravitational waves, and the Stefano Braccini Thesis Prize emphasizes the novelty and innovation of the research.

GWIC Thesis Prize

The 2015 GWIC Thesis Prize is awarded to Denys Martynov, for his thesis, “Lock Acquisition and Sensitivity Analysis of Advanced LIGO Interferometers”. Dr. Martynov received his Ph.D. from the California Institute of Technology and was nominated by his adviser, Prof. Rana Adhikari. His thesis describes his work toward the Advanced LIGO goal sensitivity for the first observation run, by characterising and mitigating various noise sources such as laser frequency and amplitude, auxiliary degrees of freedom, backscatter, and test mass actuator noise.

Denis Martynov,
winner of the 2015 GWIC Thesis Prize

“Lock Acquisition and Sensitivity Analysis of Advanced LIGO Interferometers” (PDF), California Institute of Technology



Vikram Ravi,
winner of the 2015 Stefano Braccini Thesis Prize

“Evincing the histories of the cosmic supermassive black hole and galaxy populations with gravitational waves” (PDF), University of Melbourne

Stefano Braccini Thesis Prize

The 2015 Stefano Braccini Thesis Prize is awarded to Vikram Ravi for his thesis, “Evincing the histories of the cosmic supermassive black hole and galaxy populations with gravitational waves”. Dr. Ravi received his Ph.D. from the University of Melbourne and was nominated by his adviser, Dr. George Hobbs. Dr. Ravi's thesis connects the upper limits on nanohertz gravitational waves that have been determined by pulsar timing to the astrophysics of black-hole growth and galaxy assembly.

C. Bradaschia

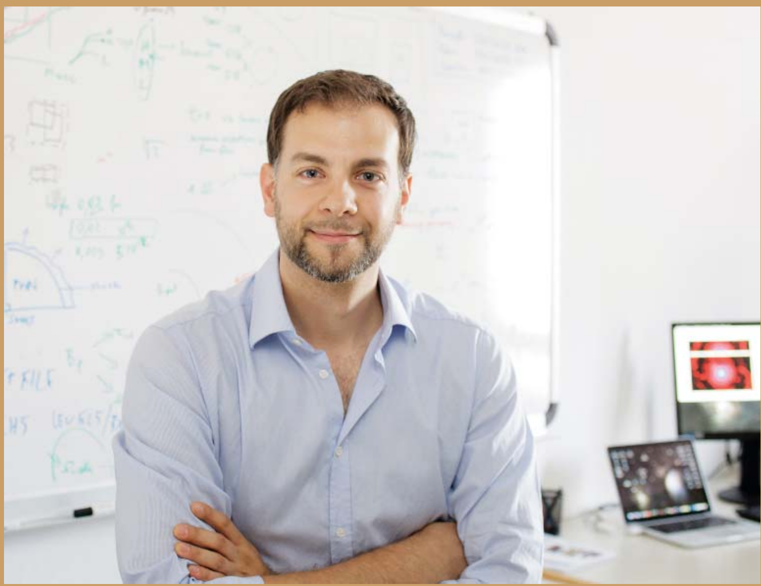
2015 VESF Prize

With the aim to encouraging new and outstanding investigations related to gravitational waves, the Virgo-EGO Scientific Forum (VESF) created an annual prize for two young scientists active in this field.
One prize is awarded to a member of the Virgo community, whereas the other is awarded to a young scientist who is not member of the Virgo community.

The prizes for the year 2015 have been awarded respectively to Annalisa Allocca and Riccardo Ciolfi.

Reprinted from https://gwic.ligo.org/thesisprize/2015/

Annalisa Allocca, *got her PhD in Physics in May 2015 at the University of Siena; currently she is a postdoc research fellow at University of Pisa. She "lives" in the Virgo Control room, working on the commissioning of Advanced Virgo, with particular attention to the optical part of the experiment.*



Riccardo Ciolfi *was born in 1983 and got his PhD in Physics in 2011 at the University of Rome "La Sapienza". In 2010, he moved to Berlin to continue his research activity at the Max Planck Institute for Gravitational Physics, where his projects were selected and funded by the Alexander von Humboldt and Angelo Della Riccia Foundations. Since 2014 he is Postdoctoral Researcher at the University of Trento.*

The Valencia Group

On July 1st 2016 our gravitational wave research group from the University of Valencia (Spain), the "Valencia group", joined the Virgo Collaboration.
This is the first Spanish group to join the collaboration.
With the addition of this new team, the Virgo collaboration now comprises six European countries, France, Italy, the Netherlands, Poland, Hungary, and, since July 1st, Spain.

The group is composed of researchers from two different departments of the University of Valencia, the Departamento de Astronomía y Astrofísica and the Departamento de Matemáticas. Its members are displayed in the accompanying photograph (next page) and they are, from left to right, José María Ibáñez, Antonio Marquina, José Antonio Font (group coordinator), Isabel Cordero-Carrión, Alejandro Torres-Forné, Nicolás Sanchis-Gual, and Pablo Cerdá-Durán. The expertise of the Valencia group is in the fields of relativistic astrophysics, applied mathematics, computing, data analysis

In particular the team has many years experience in numerical simulations of astrophysical sources of gravitational radiation and has contributed, using numerical relativity simulations, to generate waveform templates for a number of scenarios, e.g. isolated and binary neutron stars, rotational supernovae core collapse, collapsars, accreting black holes, etc. Building on this expertise the group is particularly interested in starting a new line of research in parameter estimation.
Moreover, the team is currently involved in data analysis with Total-Variation techniques for gravitational wave denoising and

waveform reconstruction.
Recently we have shown that these techniques, imported from image processing, can successfully remove noise from gravitational wave signals, irrespective of the signal morphology or astrophysical origin.

Last but not least, in close collaboration with Elena Cuoco, the group participates in ongoing detector characterization projects with colleagues from both Virgo and LIGO. The ultimate goal is to develop robust identification and classification methods for noise transients (glitches) in advanced gravitational wave detectors.

T. Font

The Valencia group (from left to right): José María Ibáñez, Antonio Marquina, José Antonio Font (group coordinator), Isabel Cordero-Carrión, Alejandro Torres-Forné, Nicolás Sanchis-Gual, and Pablo Cerdá-Durán

GWADW 2016

This year's workshop on gravitational wave advanced detectors (GWADW2016) took place between the 22nd and 28th of May. The event was organised by F. Fidecaro and S. Meshkov in the beautiful venue of the Hermitage Hotel in La Biodola, on the island of Elba.

Participation was very high (with about 160 attendees) including both VIRGO and LIGO spokespersons (F. Ricci, G. Gonzales) and the LIGO executive director (D. Reitze). Several former VIRGO members now in key roles in LIGO were also present.

A typical characteristic of all GWADWs is the intense brainstorming, not only between 'veterans' of the field and experienced researchers, but also between students and young post-docs from all over the world, in an informal and relaxed atmosphere.

This year's edition was also characterised by the elegance and perfect organisation of the venue and the extremely good quality of the food.

The event was dedicated to the impact of recent discoveries (the first and second detection events) on near term enhancements of current experiments and on future detector designs. The workshop started with several talks on what it would be possible to observe and study with second and third generations networks of interferometers [1, 2].

A summary of the expected results is shown in Table 1 (extracted from [1]): source localisation and precise distance estimate is only possible with a network of interferometers, while the most challenging and ambitious questions about cosmology and source dynamics require third-generation detectors.

These considerations should be extremely encouraging for every new-comer to the GW field, since they show that we have only scratched the surface of the science that will be done in the future.

	Sky Localization	Spin Estimation	Mass Estimation	Distances	Cosmology	Merger Physics
BNS	2GNet	2G	2G	2GNet	>2G	>2G
NS-BH	2GNet	2G	2G	2GNet	>2G	>2G
Light BBH	2GNet	2G	2G	2GNet	>2G	>2G
Heavy BBH	2GNet	>2G	2G	2GNet	2G	2G?

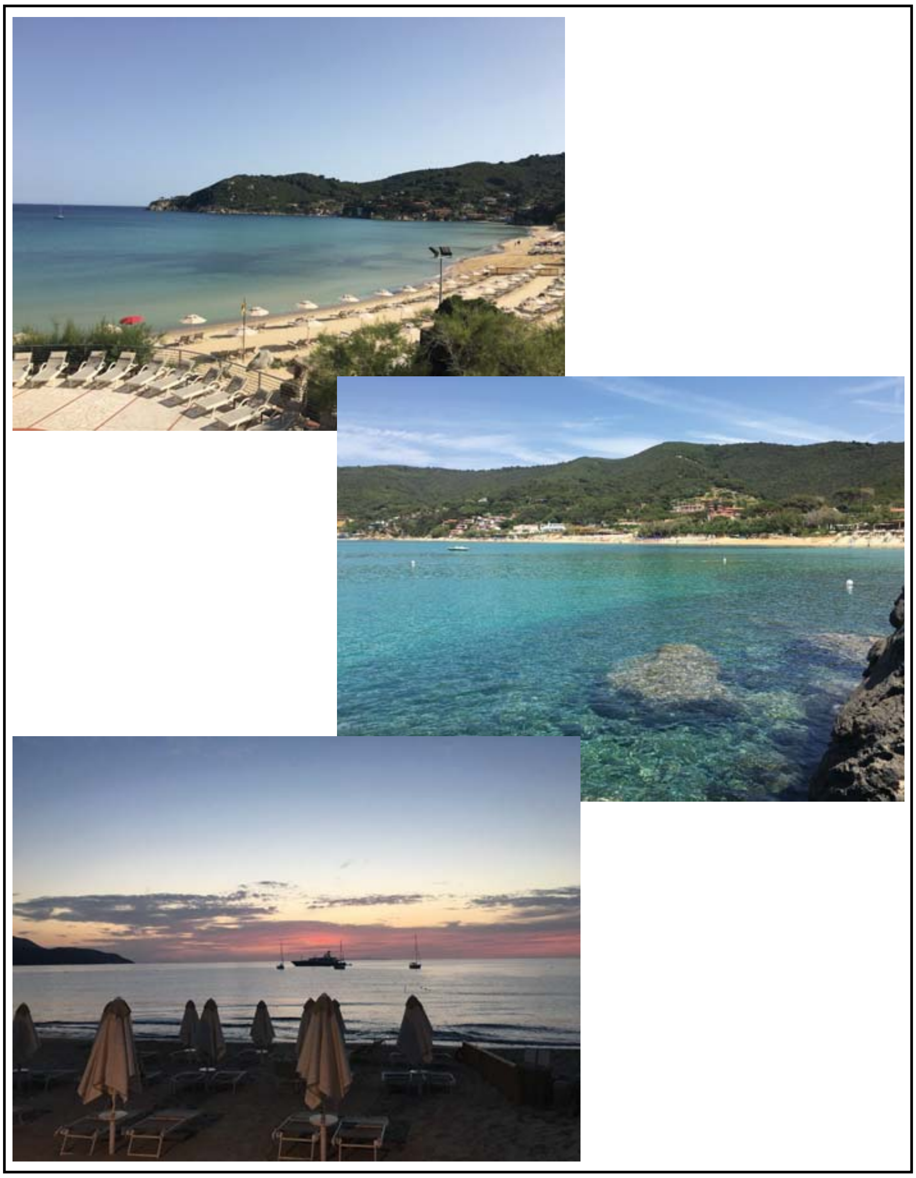
Table 1

After the introductory talks, the key part of the workshop started. Three parallel sessions were dedicated to the main lines of study for near-term detector sensitivity improvement: Low Frequency, Controls and Thermal Noise.

In order to increase the low frequency sensitivity of the detectors, we need to develop new ‘weapons’ to fight seismic and newtonian noise.
While the former is very well known and characterised, the latter, caused by the unavoidable coupling between the test masses and the gravitational field around them, is being studied and is difficult to measure [3, 4].
Another challenge for low-frequency sensitivity improvement is the measurement of the angular component of ground displacement, the so-called ground ‘tilt’, as it is known in the GW community. Since new sensors are needed for both seismic and newtonian noises, several groups are developing them (see [5, 6, 7, 8]). A particularly interesting talk in this session was dedicated to the potential use in oil exploration of seismic sensors developed for GW detectors [9].

At the same time, to increase the robustness of the detectors, new approaches to the control problems are required. The use of predictive and optimal techniques for both global control of the interferometers [10] and suspension control [11, 12] is the general trend.
This modern approach requires accurate modelling of control systems as shown in [13], where an overview of the modelling tools is given. An interesting discussion was dedicated to learning algorithms for use in the automatic tuning of detector control parameters [14].

The thermal noise session was dedicated to mirror coating enhancements. Two approaches are used to beat the mechanical losses of Tantalum Titanium



Oxide (2x10-4), the material currently used [15]: one is to use amorphous silica (a-Si) a non-crystalline form of silicon that is also employed in solar cells and LCD displays [16], the other is crystalline coating like AlGaAs, AlGaP [17].

An extremely interesting plenary session was dedicated to the near-term plans (< 12 years) for current detectors. A two-phase upgrade is expected for LIGO: first, the implementation of squeezing, and then the replacement of the current test masses to decrease thermal noise [18]. A similar approach is planned for Advanced Virgo [19].

The number of themes discussed in GWADW 2016 was really impressive and it is difficult to make a comprehensive overview. What is evident is that, thanks to the detection events, the GW field is blossoming and even the more challenging and ambitious ideas seem within reach.

V. Boschi

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[4] D. Fiorucci, Atmospheric NN modeling
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[7] A. Di Virgilio, Seismic rotational measurements
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[11] J. Kissel, MIMO damping
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[13] J. Kissel, Hopes and Dreams: One Transfer Function Fitting Program to Rule Them All
[14] R. Adhikari, Learning Methods for Interferometers
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[17] G. Cole, Minimizing test mass thermal noise with crystalline coatings
[18] L. Barsotti, LIGO: the A+ upgrade
[19] G. Cagnoli, Virgo upgrade plans

EGO Open Doors

The announcement of the gravitational wave detection on February 11th generated a worldwide media wave that also put Virgo under the spotlight and made the public much more aware of the site in Cascina.

People living in the surroundings, or who had heard about Virgo in the Italian media or even from abroad, started calling in the successive weeks and asked to visit the site.

While prior to February 11 we registered an average of 25 requests for a site visit per year, this number doubled in only a few weeks after the day of the press conference.

It was very pleasant to see how the public suddenly became so interested in the detection of gravitational waves!

Requests from groups were accepted as much as possible, considering the time a visit requires (2 hours on average) and the commitments of Virgo physicists to their activities on site, and were organised as typical 'site visit' activities.

To satisfy the requests of individuals, we collected them together on the occasion of the Open Doors day, scheduled for the seventh of May within the framework of the Science Festival organised by the Commune of Cascina, which took place from the second to the seventh of May.

A picture may be worth a thousand words. Above some photos of that day.

Thus, 3 different site tours were organised, in the morning and afternoon, and the spectacle "I Gravitons e le loro Onde" (produced in collaboration with the Teatri della Resistenza) was reproduced in the evening.

The weather was uncertain for the astronomical observations, but our friends of the Associazione Cascinese Astrofili (http://www.astrofilicascinesi.it/) were prompt to react: as soon as a window opened, they invited the visitors to look through their telescopes, which had already been installed to safely observe the Sun, Saturn or Jupiter. Visions that always fascinate the visitors!

The attendance was pretty good: activities ran at full capacity, allowing the total number of visitors to reach about 300 for the whole day.

A special big thank you goes to our guides: Annalisa Allocca, Valerio Boschi, Carlo Bradaschia, Antonino Chiummo, Diego Passuello and Massimiliano Razzano! There is no doubt that they did a good job! I report hereafter some significant comments written by the visitors:

"Thank you for the splendid day at Virgo!"

"A very warm thank you for sharing so much beauty with us."

"An incredible experience!"

"Congratulations! You are great!"
… and much more!

In addition to sharing the science of Virgo with the public, as strongly encouraged by the European Commission*, they shared their enthusiasm, which is a powerful factor in science communication.

S.Perus

** Public awareness: If scientific and technological progress is to meet the needs of Europe's citizens and regain their support, they will need to have information that is understandable and of a high quality, as well as ready access to this specific culture.*
The media, researchers, research institutions - in particular universities - as well as industry must play their public information role to the full. They must be capable of communicating and engaging in debate on scientific issues in a rigorous and comprehensible professional manner, as well as explaining frankly the benefits and limitations of scientific progress.

https://ec.europa.eu/researc/science-society/scientific-awareness /scientific -awareness_en.html

EGO VIRGO Triathlon 2016

There was a novelty this year in the venerable series of EGO-Virgo summer sports events – the Biathlon has become a Triathlon! As you know, the Biathlon always consisted of teams of athletes running along the two arms, with the total length of 12 km divided into four sections – 1 and 2 km on foot up the North arm, 6 km by bicycle between the end buildings, and finally 3 km back along the West arm.
This successful scheme has now been enhanced by a ping-pong stopover at the Start/Finish line,

2016	Ele Lab		LKB		The French Paradox		LAPPins	
1km	Beatrice Montanari		Pierre-Francois Cohadon		Matthieu Gosselin		Vincent Germain	
2 km	Simone Mastrogiovanni		Thibaut Jacqmin		Severine Perus		Loic Rolland	
Bike 6km	Roberto Cavalieri (Bob)		Tristan Briant		Eric Genin		Romain Bonnand	
Ping-pong	Andrea Pucci		Tristan Briant		Gabriel Pillant		Vincent Germain	
3 km	Tristan Shoemaker		Samuel Deléglise		Frederic Richard		Thomas Adams	
Number	4	**4**	3	**3**	2	**2**	1	**1**
Time	23:56	**43:31**	22:59	**43:03**	21:41	**40:45**	19:56	**38:15**

Fig. 1 : *Arrival sequence and the measured times after half of the Biathlon (after coming back from the North arm and completing the ping-pong part, grey) and the final numbers (white). Subtract an average of 50 sec. for the ping-pong challenge if you want to compare with previous years.*

Fig. 2: *The victorious LAPPins, proudly showing their cup*

where the bicycle rider has to stop in the middle of his 6 km ride until he or a dedicated expert has accomplished the challenge of hitting a ball, three times, over a ping-pong table into a box placed at the other end.

Four teams participated this year: Ele lab (The EGO electronicians, with the help of our American guest Tristan), LAPPins (rabbits in French), LKB from the Paris lab, and The French Paradox, referring to the seemingly contradictory fact that the French, despite a wine- and cheese-based diet, are generally in good physical shape.

At the end of a hot day, the wind became quite strong, so the ping-pong table was placed in the slipstream of the Control Building; despite this precaution, even the ping-pong experts missed the target a few times due to the unexpected perturbation.

This year all participants received special T-shirts with our Triathlon logo, and the winning team received a cup.

H. Heitmann

New faces at EGO

Over the last few months I am very pleased to have met new faces at EGO: young local students (maturandi), Grawiton students and international experimented scientists dispersed in various EGO Departments.

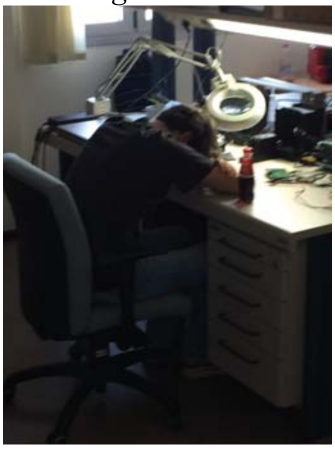
Here are depicted a few of them who you have certainly passed in the corridors

Koki Okutomi is a young Japanese scientist currently working at KAGRA on the suspension system.
He has just left the EGO site after working for one month on the suspensions with Paolo Ruggi.
Koki is interested in better understanding how our suspensions work, the control strategy developed over the years at Virgo and the way we tune the whole system
Koki cannot stay longer with us as a lot of work is waiting for him to do with the suspension.
Their funding institution promise to start a run with their interferometer using cryogenics by 2018!

Tristan Shoemaker is a lively 19 year old student at Mac Gill University (Montreal, Canada) who has already completed the first two years of study needed to obtain a bachelor's degree in physics.
He is currently working with Irene Fiori and the Commissioning team for two months, giving his contribution to Detector Characterization studies, and had lost no time having already posted a few entries in the Virgo logbook.
He is fitting in well in Virgo/EGO having already participated in various social events organized by EGO/Virgo people.

Marina Trad Nery is a Brasilian PhD student, who currently works in Germany as a Grawiton student.
She is at EGO for a month and a half to work on Commissioning and Injection system under the supervision of Eric Genin.
She will complete her PhD two years from now.
Meanwhile, we will certainly see her again in the Control Room.

A well-deserved moment of relaxation during lunch time!



Andrea Pucci, Giacomo Arcuri, and Superman (Lorenzo Vernaccini) are here from the Istituto Tecnico Industriale Statale di Livorno for three weeks. They are working on IMMS (Infrastructural Machine Monitoring System). Their duties imply the mounting and characterization of printed circuit board in the electronics lab and sensors installation in the Central building.

Nota Bene: I kindly ask their EGO supervisor Roberto Cavalieri to not overwhelm them with too much work in order to avoid any gravitational collapse ...:

Vincent Pêcheur is a French student currently doing a masters degree in Optics who joined EGO last February
He has worked for 5 months in the EGO Optics group under Eric Genin's supervision on the development and characterization of a high resolution optical spectrum analyser (to control the arms symmetry,i.e. the monitoring of the side band amplitude).
He would like to continue his studies by doing a PhD in optics.

Vincent has been appreciated during his stay for his good mood and his ping-pong skills, which he developed at lunchtime with EGO and Virgo colleagues

Susan Blackburn was born in Canada and is currently studying Physics at Columbia University (New York) after working for many years in Sudan, Lebanon and Nicaragua for the Red Cross.

Thanks to an NSF grant, she decided to work for 2 months on our experiment with Irene Fiori and Jan Harms on Newtonian noise modeling.

F-M.Richard

From Pisa to Japan in a quarter of a century

1990 : It's April and I am looking for a subject for my master's thesis. These mysterious gravitational waves look really fascinating and I decide to visit Adalberto Giazotto's laboratory.
His office is inside a kind of industrial building at the Pisa INFN Laboratory in San Piero a Grado. Just in front of his office there are two tall vacuum chambers facing each other.
One of the chambers is open. Inside there is a chain of cylinders each suspended from the one above it. A hook at the bottom seems to say that something should be hanging there: it's the mirror. Adalberto hands me a big green book.
On the front cover is written: "The Virgo project". I ask when are we going to start looking for gravitational waves. "It's written in the book" he answered. He opens the book and shows me a plan. According to the plan, data acquisition should start in 1997.

The first superattenuator prototype in San Piero a Grado

The site of the central building shorthly after start of the costruction works

It looks far-off to me. But I am a bit naïve. The project is not even approved yet. The lesson is: there is a lot to learn from your supervisor ….. but do not trust him too much ….

1996: Now it is clear. Data acquisition will not start in 1997. But the project has been approved and the construction has finally started.
I now work in France at LAPP, Annecy, but I come to Pisa very often for the Virgo collaboration meetings. From Annecy I hear that the construction has just started. As soon as I arrive in Pisa I decide to jump in the car and have a tour of the Virgo site together with my fiancée.
The picture above shows what I saw. That's the place where the central building is going to be. Difficult to imagine that a 3km-long interferometer is going to appear in such a place.

2001: I am back in Pisa. CNRS sends me back to my home town to work on the start-up of Virgo. It's a very interesting job and I am lucky: I work with a group of number ones.
Some of them are in the picture in the next page.
Naming all of them would be too long. Just one name: Stefano. Without him we wouldn't be able to laugh even when nothing was working as we wanted.
The commissioning of Virgo will last for much longer than we had anticipated. But in the end we managed to get Virgo operating.

2007: Finally the first Virgo Scientific Run is going to start.
I am in Baton Rouge at the LIGO scientific collaboration meeting. Edwige, the Virgo commissioning coordinator, cannot come and I have to present the status of the Virgo commissioning to our LIGO colleagues.
At the time, the detector is able to see the coalescence of binary neutron stars up to distances of 2 to 3 Mpc. The LIGO detectors are sensitive up to above 10 Mpc.
I do my best to show the progress we made and the plans for further improvements.
At this same meeting, the Council of the Ligo Scientific committee has to discuss the approval of an MoU between LIGO and Virgo. According to the MoU we should start working together: operate the interferometers jointly,

share the data and analyse them together. It is a paradigm shift: from competition to collaboration. It is the nice aspect of our field. We have to do it, if we want to get the best science out of our efforts.
Benoit, the Virgo Spokesperson, asks me to go with him to the meeting of the council where the MoU will be discussed.
It's like entering an arena. More than 100 delegates will discuss and then vote yes or no. We do not have to do much. Just listen and, if necessary, answer questions. The LIGO and Virgo management wants the agreement and the agreement is finally approved with a very large majority.

From left to right:
Raffaele Flaminio, Matteo Barsuglia, Matt Evans, Lisa Barsotti, Federico Nenci e Stefano Braccini

2015: It's September 14th. I am in Japan. It's just before dinner. An email arrives from Hannover. It is addressed to the 'DAC' mailing list.
The 'DAC' mailing list is one of the LIGO-Virgo mailing lists that can fill my e-mail box very easily. There are so many emails on the LIGO-Virgo mailing lists that I have developed a 6th sense to figure out if I have to read it or discard it just by reading the subject line.
The subject of this email is quite clear "Very interesting event in ER8". It's another Italian expatriate (the LIGO and Virgo collaborations are packed with Italians working abroad) that is sending the email from Germany. I open it and read it. Indeed it is an interesting one. Marco is pointing us to a very interesting trigger detected by one of the online pipelines that continuously analyse the data and tells us if something interesting is going on.
Usually all LIGO-Virgo events always take place when it's late at night in Japan. But gravitational waves do not care about time zones and this "very interesting event" has been nice with me: it's my appetiser.
Marco is asking if somebody injected a fake signal into the LIGO detectors.

Shortly the answer arrives from Australia (or at least the email comes from there): "no, no signals injected". The next email is from France. It says "very interesting event. Seems to be the inspiral of two high mass compact objects. Why did the on-line coalescing binary searches not send a trigger?". The following emails are from the US. It is early morning there and they are waking up. The first says that the "data quality is very good". But the most convincing e-mail is the following one. It comes from Florida. It is possible to imagine Sergey's Russian accent just by reading the email "It's a nice inspiral with a chirp mass equal to twenty seven solar masses …… If it is not an injection we need to do a detection check list!" Wow!! The cherry on the cake arrives shortly after: "Very interesting. The coalescing binary online searches do not look for chirp masses above 5 solar masses". That closes the circle. Everything fits. We only need to make sure that it is not a blind injection. For that, the best possible Sherlock Holmes's are sent to the LIGO sites. And they confirm …. we need to go through the detection checklist!

A quarter of a century after I started my master's thesis with Adalberto, the goal is finally achieved. Gravitational waves do not simply exist, as we have been repeating at all conferences for decades, but we have also started detecting them.
Finally gravitational wave astronomy can begin!

R.Flaminio

Galileo was 1600 years late…

This title may seem surprising and even disrespectful; but it tells the truth.

It refers to something that I have recently learned, following a discussion with Diego Passuello.

The issue is the following…

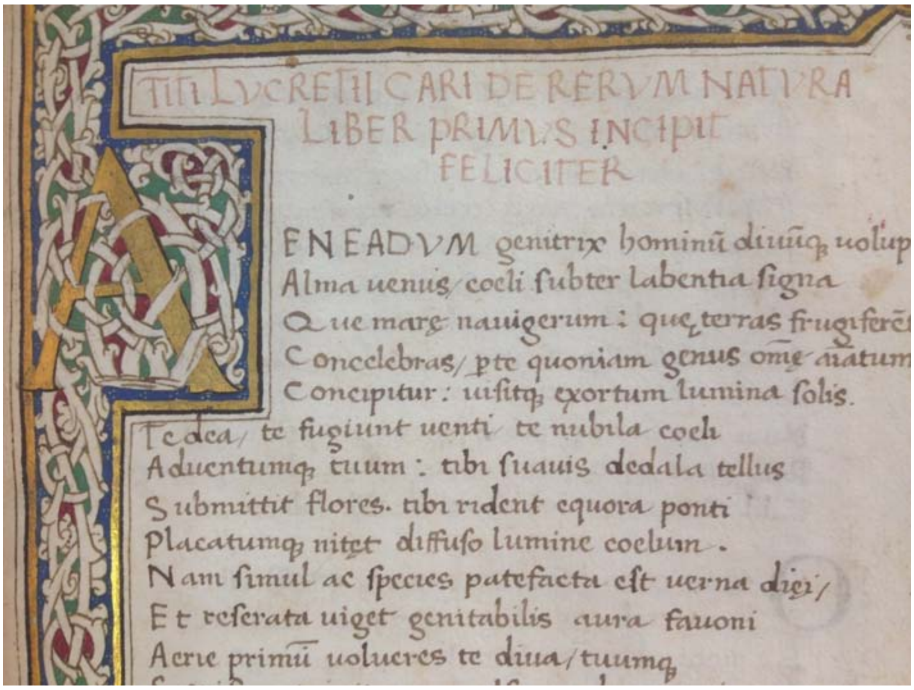
As is well known, Galileo intuited the universality of the free-fall law: all bodies, independent of their weight and shape, fall, in vacuum, with the same acceleration.

Not having the means to make a vacuum, he reached this conclusion by extrapolating from the results of many experiments on the falling of various different objects in atmospheric air and in water.
Tradition tells of falling stones and feathers from the top of the Pisa tower (which is suitably inclined!).

Well, the Roman scientist, philosopher and poet, Lucretius, in the first century B.C. reached the same conclusions with simple reasoning, in the "liber secundus" (the second chapter) of his poem "De Rerum Natura" (On the Nature of Things - https://en.wikipedia.org/wiki/Lucretius).

Of course, I am not claiming that Galileo copied the intuition of Lucretius; I am instead surprised that Lucretius's conclusion is so little known, while the many fantastic (and wrong) statements of others, such as Aristotle, are common knowledge.

For your amusement, the original text by Lucretius, in Latin and its translation into English, are available below.
There then follows a passage from Galileo's "Discorsi e dimostrazioni matematiche intorno a due nuove scienze" (Discourses and Mathematical Demonstrations Relating to Two New Sciences - https://en.wikipedia.org/wiki/Two_New_Sciences) on the same subject.



A manuscript of De Rerum Natura in the Cambridge University Library collection.

Titus Lucretius Carus
First century b.c.
De rerum natura II, vv. 230-240
....
nam per aquas quae cumque cadunt atque aera rarum,
haec pro ponderibus casus celerare necessest
propterea quia corpus aquae naturaque tenvis
aeris haud possunt aeque rem quamque morari,
sed citius cedunt gravioribus exsuperata;
at contra nulli de nulla parte neque ullo
tempore inane potest vacuum subsistere rei,
quin, sua quod natura petit, concedere pergat;
omnia qua propter debent per inane quietum
aeque ponderibus non aequis concita ferri.

For whatsoever through the waters fall,
Or through thin air, must their descent,
Each after its weight- on this account, because
Both bulk of water and the subtle air
By no means can retard each thing alike,
But give more quick before the heavier weight;
But contrariwise the empty void cannot,
On any side, at any time, to aught
Oppose resistance, but will ever yield,
True to its bent of nature. Wherefore all,
With equal speed, though equal not in weight,
Must rush, borne downward through the still inane.

(translation by William Ellery Leonard
– American poet and playwright – XX century)

DISCORSI E DIMOSTRAZIONI MATEMATICHE INTORNO A DUE NUOVE SCIENZE

GALILEO GALILEI

SALVIATI:
.......solo uno spazio del tutto voto d'aria e di ogni altro corpo, ancor che tenue e cedente, sarebbe atto a sensatamente mostrarci quello che ricerchiamo, già che manchiamo di cotale spazio, andremo osservando ciò che accaggia ne i mezzi più sottili e meno resistenti, in comparazione di quello che si vede accadere ne gli altri manco sottili e più resistenti: che se noi troveremo, in fatto, i mobili differenti di gravità meno e meno differir di velocità secondo che in mezzi più e più cedenti si troveranno .... parmi che ben potremo con molto probabile coniettura credere che nel vacuo sarebbero le velocità loro del tutto uguali ……

SALVIATI:
.... no medium except one entirely free from air and other bodies, be it ever so tenuous and yielding, can furnish our senses with the evidence we are looking for, and since such a medium is not available, we shall observe what happens in the rarest and least resistant media as compared width what happens in denser and more resistant media. Because if we find as a fact that the variation of speed among bodies of different specific gravities is less and less, according as the medium becomes more and more yielding, ... then we are justified in believing it highly probable that in a vacuum all bodies would fall with the same speed ....

C.Bradaschia