Introducing new IOMP ExCom members and Awardees

PHASE CONTRAST RADIOGRAPHY

P. Russo[1]

[1] Università di Napoli Federico II/Dipartimento di Fisica “Ettore Pancini”, Napoli, Italy

Abstract— **We briefly review the basic aspects of 2D radiography based on contrast generated by phase change of the X-ray wave passing through an object and around its boundary. Laboratory radiographies on test objects are shown for illustrating the principle of propagation based phase contrast imaging.**

Keywords— **X-rays, complex refractive index, radiography, phase contrast imaging.**

I. INTRODUCTION

For about 100 years, since Wilhelm Conrad Röntgen’s discovery in November 1895 [1], radiography has been based on the principle of X-ray attenuation in matter, i.e. the recording of an intensity map from differential absorption and scatter off atoms and molecules by incident X-ray photons along different ray paths. After Max von Laue in 1912 demonstrated the nature of X-rays as electromagnetic waves in analyzing the structure of crystals, with the prompt interpretation given by Lawrence Bragg in his well-known equation, the analysis of the transmitted hard X-ray beam through non-crystalline materials in radiography was restricted to the consideration of interactions by X-ray quanta (i.e. photoelectric absorption, Rayleigh scattering from atoms and Compton scattering from free electrons), rather than as transmission, reflection and refraction of the X-ray wave in matter. This might stem from the initial difficulties, experienced by Röntgen and later investigators, to produce refraction of X-rays by means of prisms of various materials. Indeed, in his experiments in 1916 on refraction of Br Kα X-rays by a KBr crystal, Charles Glover Barkla concluded that the refractive index at a wavelength of 0.5 Å differed from unity by less than 5×10^{-6} [2] (i.e. the refractive index decrement $\delta < 5\times10^{-6}$, where the complex refractive index of the material at wavelength λ is $n(\lambda) = 1 - \delta(\lambda) - i\beta(\lambda)$, with β the material’s absorption index). Note that for energies far away from atomic absorption edges, δ for compounds is directly proportional to the effective electron density, ϱ_e^{comp}, of the material: $\delta_{\text{comp}} = (r_e\ \lambda^2/2\pi)\ \varrho_e^{comp}$.

Due to its small cross section, small-angle Rayleigh scatter was essentially considered negligible for photon energy in the diagnostic range (10-150 keV), apart from X-ray mammography where average photon energies are in the range 15-20 keV, and Rayleigh scatter events represent less than 12% of all interactions in soft tissue below 30 keV. Compton scatter, on the other hand, has commonly been considered as a source of image blurring and degradation of the radiographic contrast in transmission projection radiography, with the common adoption of anti-scatter grids, air gaps or post-acquisition deconvolution algorithms as procedures able to reduce the scatter-to-primary ratio. Hence, traditionally, X-ray scatter has been considered as a negligible or detrimental contribution to the image quality in planar transmission radiography. On the other hand, wave phenomena in X-ray propagation in matter have a fundamental role in Physics, and Arthur Holly Compton, in December 1927, Nobel Prize in Physics "for his discovery of the effect named after him", in his Nobel Prize Lecture discussed “X-rays as a branch of Optics”.

Advancements in X-ray imaging techniques produced, in the last 20-25 years, a new type of radiography, based on the differential phase changes of a transmitted X-ray electromagnetic wave along different ray paths in the object: *phase contrast radiography*.

II. THE ORIGINS OF X-RAY PHASE CONTRAST IMAGING

In the years 1995 and 1996 an increasing number of scientific papers reported on a new technique for X-ray radiography of non-crystalline objects – developed by Russian physicists and already contained in 1991 and 1992 patents [4] – which investigated the slight changes in the X-ray wave front corresponding to phase changes of (pseudo)plane beams at the external boundary and at internal interfaces between internal structures of a non-homogeneous object [5]. All these initial observations and future additions and implementation introduced the so-called phase contrast X-ray imaging field. In 1995, a group at the Photon Factory in Tsukuba (Japan) reported in the journal “Academic Radiology” experiments carried out as early as in 1994 on imaging of metastatic liver cancerous lesions with synchrotron radiation, with cancer tissue contrast originating from phase contrast rather than from absorption contrast, concluding that “… X-ray phase-contrast imaging better differentiates tissues than does the absorption contrast imaging commonly used in radiology” [6]. In early 1996, the medical physics journal “Physica Medica” published an article on “phase dispersion radiography” [7], reporting applications of imaging optically-thin biological objects like e.g. small fishes, where subtle internal details where visible with high contrast in such low-attenuating (few-mm thick) biological objects. Indeed, the first observations of subtle changes in the wave front by objects inserted in the beam due to X-ray refraction were serendipitous: the observed intensity variations were discovered in X-ray diffraction topography investigations of crystalline objects, and found to be due to the undulations of the velvet fabric covering the crystal under investigation [5]. Additional investigations by this group on imaging vessel structures in living organisms and animal cadavers confirmed the promise of *in vivo* imaging of soft tissues without contrast agents [8].

The experimental setup for the X-ray optic system (Fig. 1) included usually a crystal analyzer for angular-resolved analysis of the diffraction pattern from objects irradiated with monochromatic pseudo-plane waves produced by an X-ray source and a single or double crystal monochromator [5]. Indeed, wave front deformations by phase gradients, $\partial\varphi/\partial x$, introduced by refractions at the object boundary and in the object, at the interface of materials with different index of refraction, introduce angular deviations, $\Delta\alpha$ (in the range of μrad), of the X-rays (wavelength, λ) with respect to the propagation direction, z, which can be sensed by this differential phase contrast methods, via:

$$\frac{\partial\varphi(x,y)}{\partial x} = -\frac{2\pi}{\lambda}\Delta\alpha \,. \qquad (1)$$

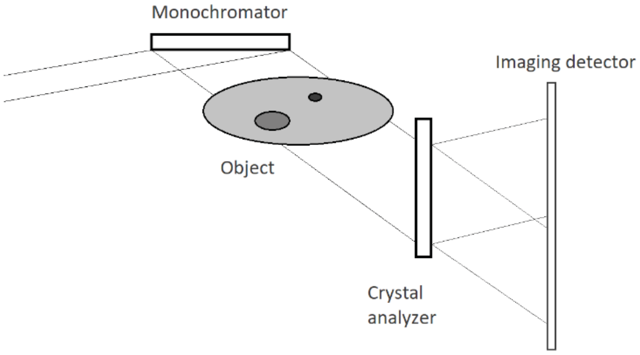

Fig. 1 Setup for analyzer based phase contrast imaging with a double-crystal Bragg-Laue optical scheme (adapted from ref. 2, fig. 1).

The retrieval of projected (z-integrated) phase shift maps $\varphi(x,y)$, e.g. from spatial integration of phase gradients $\frac{\partial\varphi}{\partial x}$ as in eq. 1, produces images in so-called *phase radiography*.

The analyzer based methods are simpler to implement than interferometric methods (e.g. with the Bonse-Hart crystal interferometer [9]), in which the transmitted X-ray wave front interferes with a (analogously coherent) reference beam and a 2D imaging detector records the interference fringe pattern (Fig. 2).

In the presence of a highly coherent, monochromatic X-ray beam from a synchrotron radiation source, a form of in-line holography was investigated at ESRF (Grenoble, France), now known as phase contrast propagation based imaging (PBI) [9]. In their experiments, a high resolution imaging detector placed at a distance up to 2 m behind the object (located at 40 m from the X-ray source) records the interference pattern produced by the superposition of the incident, quasi-parallel (spatially coherent), monochromatic beam with the beam scattered by the object.

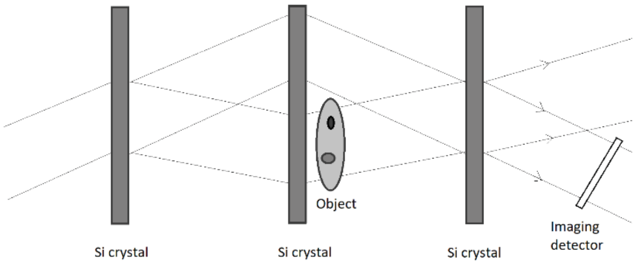

Fig. 2 Setup crystal interferometer based phase contrast imaging with a triple-crystal Laue optical scheme.

In PBI – an imaging technique which does not require any optics downstream of the object to analyze the transmitted beam – interference phenomena show up in the image signal as white and dark fringes at the boundary of the object and at any interface between internal structures of different index of refraction $n(\lambda)$. Low attenuation objects (e.g., 10-μm cellulose or beryllium fibers, or capillaries with 10-μm external diameter, in ref. [9]) are best suited to illustrate this phenomenon of X-ray refraction, due to spatial changes in the real part, $(1-\delta)$, of the refractive index of the object. Note that δ may be three orders of magnitude greater than β (Fig. 3).

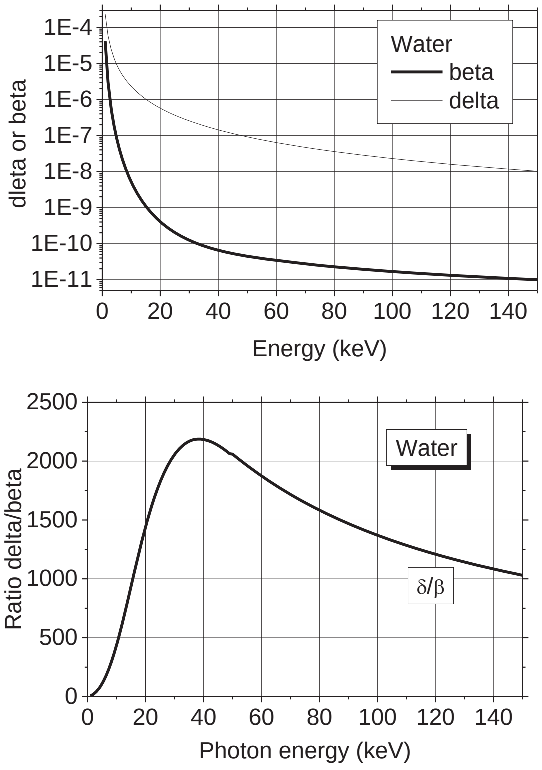

Fig. 3 (Top) The refractive index decrement, δ, and absorption index, β, for liquid water, in the range 1–150 keV. (Bottom) Ratio of δ to β for water.

The scheme for PBI is shown in Fig. 4. Under condition of the detail size $d^2 >> (\lambda z)$ – a condition easily realized for features micrometer-sized or larger, for hard X-rays and for propagation distances z realizable in the laboratory – the phase contrast signal on the detector is proportional to the transverse Laplacian $\nabla^2\varphi(x,y)$ of the wave front phase profile. Hence, registration of the transverse intensity profile in the imaging plane and a double spatial integration allows to derive the projected phase map of the object.

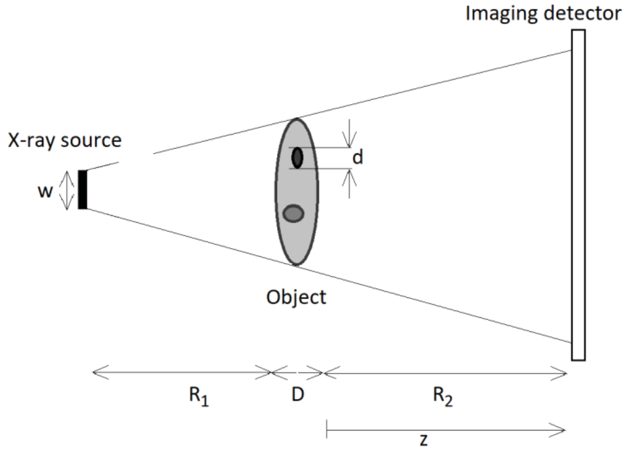

Fig. 4 Scheme of propagation based phase contrast imaging. The object size D is typically negligible with respect to the propagation distance $z = R_2$. Quasi parallel beam irradiation geometry occurs for large source-object distance, R_1. d is the size of the smallest resolvable detail in the object. Suitably large distances R_1 or small source size w (i.e. high spatial coherence) and suitably large R_2 between object and the high-resolution imaging detector, produce edge enhancement effects in the projected image at the boundary of the object and at internal interfaces between details of different refractive index decrement with respect to the surrounding material.

Following the phase retrieval algorithm for PBI developed by the CSIRO group in Australia [10], it can be shown [11] that the phase map can be recovered from a phase contrast image at a single distance R_2, as follows:

$$\varphi(x,y) = \frac{1}{2}\frac{\delta}{\beta}\cdot ln\left(F^{-1}\left\{\frac{F[I(x,y)/I_0(x,y)]}{1+\left[\frac{\lambda z\delta}{4\pi\beta}\right](u^2+v^2)}\right\}\right). \quad (2)$$

In eq. 2, F is the direct and F^{-1} the inverse Fourier transform operator, (u, v) are coordinates in the Fourier spatial frequency space conjugated to (x,y) in the spatial domain, I is the signal intensity map in the image plane with the object in the field and I_0 the intensity map without the object. Eq. 2 is valid in the near-field ($z << d^2/\lambda$) for objects with spatially uniform value of the ratio δ/β, and for a monochromatic source at large distance from the object (quasi parallel geometry).

Though the requirement of spatial (lateral) coherence of the incident X-ray beam is a condition for phase contrast imaging (with the coherence length $L_\perp = \lambda/\theta$, where θ is the angular width of the source from the observation point) it has soon been recognized that the requirement of temporal coherence (monochromaticity) is not strict: even using the polychromatic X-ray spectrum from an X-ray tube, the different spectral contributions may be expressed by an “average” wavelength $\bar{\lambda}$, and edge enhancement effects are still clearly visible as sharp white/black fringes at the boundary of zones of different thickness in the object or at interfaces between regions of different refractive index, in PBI. In a pioneering paper [12], the Australian group showed that the high spatial coherence could be achieved by a microfocus X-ray tube (having a focal spot size of 20 μm or less) with the focal spot at a distance, R_1, as close as ~0.5 m from the object, giving a lateral coherence length of $L_\perp \approx$ 1.5 μm at 20 keV effective energy: for comparison, $L_\perp \approx 9$ μm for the low-divergence (~1 mrad) synchrotron radiation experiments at 14 keV at ESRF [9]. The use of a (micro)focus X-ray tube for PBI gives promise of its clinical applicability, with respect to a synchrotron radiation source. However, the low output of microfocus X-ray tube due to low tube current (typically below 1 mA) and the divergence of the X-ray beam (20–40 deg) limit the X-ray flux on the detector plane, if the distance, R_2, from the object to the detector is too large (e.g. greater than 0.5–1 m). This is a major impediment to the application of the PBI technique with a microfocus source; a viable solution might be the increase of the tube voltage to increase the tube output [13,14]. Indeed, in PBI, the transmitted beam should propagate through sufficiently large distances behind the object for interference effects to develop. The quantity “shear length” has been introduced, $L_{shear} = \bar{\lambda}R_2/MD$, where R_1 is the source-object distance, $M = (R_1 + R_2)/R_1$ is the image magnification and D is the minimum size of the target spatial non-uniformities in the object [15]. Hence, in PBI, phase contrast effects (e.g. edge enhancement) may be fully visible (independently of the X-ray wavelength) if the degree of spatial coherence in the incident and transmitted waves are such that $L_{shear} << L_\perp$, with only partial visibility occurring for $L_{shear} < L_\perp$.

The photoelectric absorption coefficient μ_a is related to the absorption coefficient via:

$$\mu_a = -\frac{4\pi}{\lambda}\beta, \quad (3)$$

while the wave phase shift $\Delta\varphi$ is related to the refractive index decrement δ and to the object thickness, D, via:

$$\Delta\varphi = -\frac{2\pi}{\lambda}\delta\cdot D. \quad (4)$$

The rate of phase change in the wave propagation in the material can be quite sizeable, in the order of tens of radians per mm in the diagnostic energy range (Fig. 5).

X-ray phase imaging via grating interferometry has been continuously developed in the last 15 years. It exploited the high sensitivity of the Talbot-Lau optical scheme for deriving phase maps by integration of the signal proportional to the phase gradient, combined with the use of the X-ray tube from a conventional radiographic unit (i.e. with large focal spots and high tube power), a key feature for clinical applicability [16,17]. Moreover, such grating interferometric methods allow also to derive the absorption map and a darkfield image of the sample.

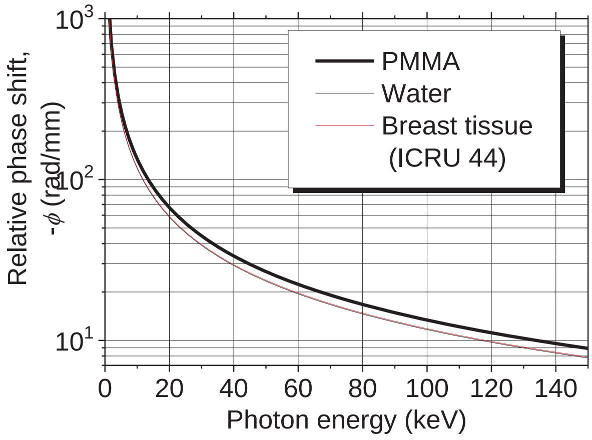

Fig. 5 Rate of change of the X-ray wave in the range 1–150 keV for plexiglas (PMMA), liquid water and breast tissue. The two last curves are almost coincident.

X-ray Talbot-Lau grating interferometers employ three (gold) transmission grating (amplitude grating G0, phase grating G1 acting as a beam-splitter of the first two diffraction orders, and amplitude grating G2 acting as an analyzer) placed, respectively, downstream of the source, downstream of the object and upstream of the detector (fig. 6) [16-18]. At each site of refraction, the object introduces a phase change and a slight refraction in each beamlet, which is proportional to the gradient of the phase shift, given by eq. 1.

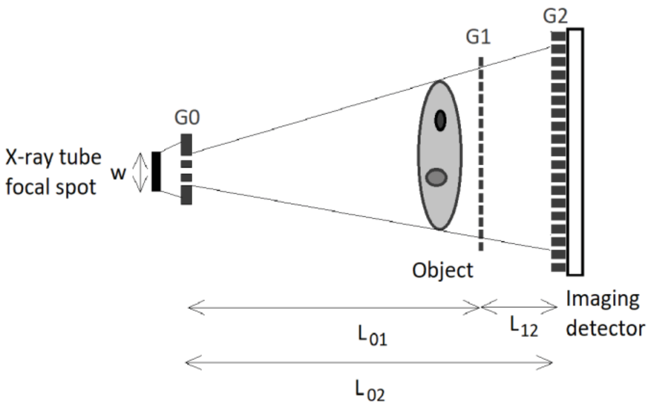

Fig. 6 Optical scheme of an X-ray Talbot-Lau grating interferometer for phase imaging (adapted from ref. 14, fig. 1).

The set of gratings G1 and G2 allows to record the differential phase changes introduced by the perturbation of the wave front by the object as lateral displacement of the fringe pattern and consequent changes of the local intensity on the detector, and a spatial integration along the direction *x* provides the map of phase changes in the object. Then, a so-called phase-stepping procedure is usually applied, which allows to distinguish intensity variations due to the phase shift introduce by the object, from other sources such as absorption in the object, uneven irradiation or defects in the gratings: this is done by scanning at high resolution one of the gratings in the lateral direction *x* so as to cover a distance of one period of the grating. The pitch of the gratings is in the order of micrometers and their open fraction is in the order of 1:2. The imaging spatial resolution is wL_{12}/L_{01}, where *w* is the size of the source. The grating G0 produces an array of period $p_0 = p_2 L_{01}/L_{12}$ of micrometer-sized "line sources" and determines high spatial coherence in the X-ray incident beamlets. G1 produces a periodic interference pattern of period p_1 (introducing a phase shift of $\pi/2$ or zero) whose intensity oscillations along the distance L_{12} have maxima at the periodic distances $L_{12\max}$. G2 consists of a periodic array of absorbing structures which transforms the changes in the interference fringe pattern produced by G1, into changes in X-ray intensity at the high-resolution detector plane. Its spatial period is $p_2 = p_1 L_{02}/L_{01}$.

Edge illumination is another form of X-ray phase-contrast imaging, first developed at ELETTRA synchrotron radiation facility in Trieste, Italy, and then at University College London, with non-stringent requirements for the temporal and spatial coherence of the X-ray beam, permitting to adopt table-top and clinically viable experimental setups with high-power (large focal spot size) X-ray tubes. Here, a slit (e.g., ~10 μm) upstream of the object ("sample slit") generates a thin transmitted beam which is analyzed by a second slit ("detector slit") in front of the detector, slightly misaligned with respect to the first slit (Fig. 7) [19]. The detector slit is precisely aligned with a row of pixels in the imaging detector. A part of the transmitted beam is stopped by the detector slit and the remaining part irradiates the detector.

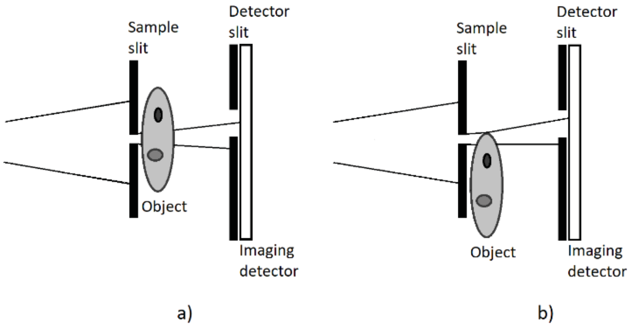

Fig. 7 Scheme of the edge illumination technique for phase contrast imaging. The sample slit is slightly misaligned with respect to the detector slit. The incident beamlet on the object can be partially absorbed (as in *a*) and refracted (as in *b*), determining a change of the photon fluence on the detector. The object is translated across the beam to obtain an absorption and phase image (adapted from ref. 19, fig. 1).

The signal intensity on the detector is decreased by X-ray attenuation in the sample (Fig. 7a). On the other hand, refraction of the X-ray beam by the object (following eq. 1) also changes the total intensity reaching the detector through the detector slits (Fig. 7b), so that a differential phase map (superimposed on the absorption map) can be obtained by recording the transmitted image while scanning the object through the beam.

III. PROPAGATION BASED PHASE CONTRAST RADIOGRAPHY: EXAMPLES

In the following we show some radiographs, taken with a table-top micro-radiography system comprising a microfocus X-ray tube with a 7 μm focal spot size, a flat panel detector with 50 μm pixel pitch or a photon counting detector, and a source-to-image distance of less than 1 m, for the purpose of illustrating the effects of propagation based phase contrast radiography.

Fig. 8 shows the comparison of a conventional contact radiograph of a small flying insect, and a radiograph of the same sample acquired at magnification M = 7. For a detail spatial frequency of 10 lp/mm, one has $L_{\text{shear}} / L_{\perp} = 0.06$ and the condition is fulfilled for a partial visibility of phase contrast effects. These show up as clear identification of the thinnest and very low contrast details like the wings of the insect, which show essentially null area contrast but well identified edges.

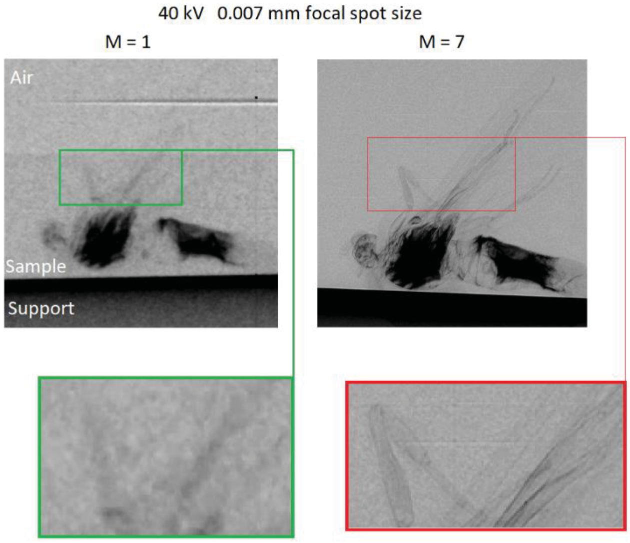

Fig. 8 (Left) Contact radiograph (image magnification factor $M = 1.01$, $R_1 = 715$ mm, $R_2 = 9$ mm) of a moth (a common flying insect, less than 2 cm long), taken at 40 kV with a high resolution flat panel detector (50 μm pixel pitch) and a microfocus X-ray tube with a 7 μm focal spot size. The low attenuation ($I/I_0 < 0.01$) gives low contrast for the thinnest body part, as for the wings shown in the zoomed image of the bottom panel. (Right) Phase contrast radiograph ($M = 7$) of the moth acquired at 40 kV with increased tube loading (mAs), but with $R_1 = 103$ mm, $R_2 = 621$ mm. The phase contrast image shows fine details of low contrast parts like the wings (see zoomed detail in the bottom panel on the right), thanks to the edge enhancement effect occurring at the boundary of the sample (adapted from ref. 20).

Fig. 9a shows a magnification radiograph of a beetle, acquired with the above microfocus X-ray imaging setup. With respect to the sample of Fig. 8, this represents a relatively high absorbing object, given the larger size and the presence of a thick exoskeleton of the red palm weevil. With $L_{\text{shear}} / L_{\perp} \cong 0.05$, some limited edge enhancement effects can be observed (Fig. 9b), as low-amplitude undershoot and overshoot of the line profile across boundaries.

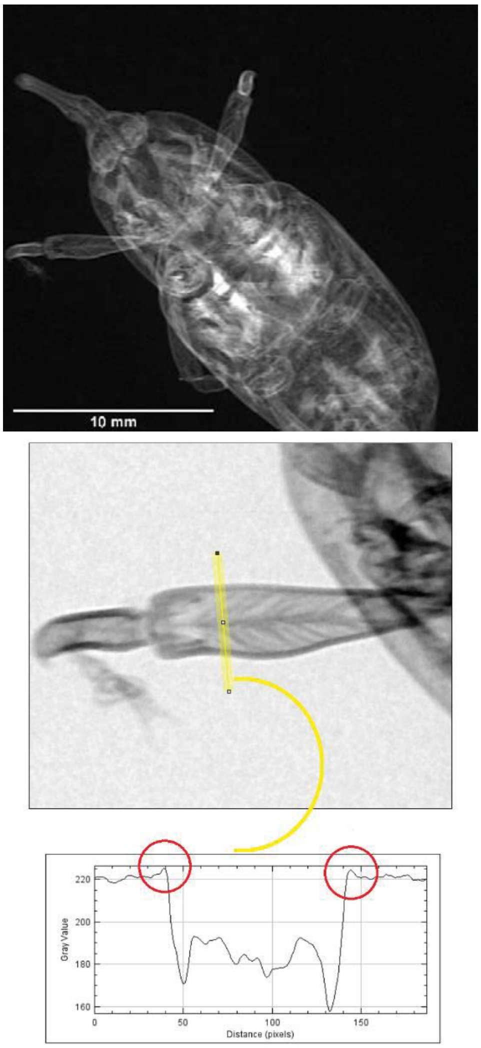

Fig. 9 (Top) Phase contrast radiography of a beetle “red palm weevil” (*Rhynchophorus ferrugineus*), taken at 80 kV with a microfocus X-ray tube (7 μm focal spot size) with a magnification $M \cong 4$, $R_1 \cong 250$ mm, $R_2 \cong 750$ mm. (Bottom) Detail of the left-side leg: a line profile across the leg shows some edge enhancement effect (overshoots circled in the line profile plot).

In Fig. 10, the use of a photon counting imaging detector (Medipix2 with Si pixel detector, 55 μm pitch, 256 × 256 pixels) allowed to improve the detector spatial resolution to 9.1 lp/mm and to increase the signal-to-noise ratio. Here, the focal spot size of the microfocus X-ray tube is set to 5 μm and the magnification is $M = 9.1$.

Fig. 10 Phase contrast radiograph of an ant taken at 40 kV, 20 mAs, with a microfocus X-ray tube (5 μm focal spot size) and with a magnification $M = 9.1$, $R_1 = 68$ mm, $R_2 = 552$ mm (from ref. 21). Important edge enhancement effects are visible, which permit to clearly delineate the silhouette of all low-absorption details of the insect.

IV. CONCLUSIONS

Phase contrast radiography exploits X-ray wave refraction when crossing interface between regions of different values of the refractive index decrement δ, for generating contrast. Then, phase retrieval algorithm may provide phase radiographs of weekly or moderately attenuating objects, the phase map being proportional to the local effective electron density of the object. Various fields are under investigation for application of such techniques in the clinical practice, including e.g. lung imaging and 2D mammography. 3D tomographic techniques based on these X-ray wave phenomena are also well advanced. Its potential for improving the image contrast is large, at radiation dose levels not largely differing from those of attenuation based radiography. The role of the various phase contrast and phase imaging techniques (interferometric, propagation based etc.) in the clinic is still to be disclosed, with medical physicists leading the edge of this frontier research.

ACKNOWLEDGMENT

The author thanks Prof. S. Tabakov for the possibility to publish this article.

REFERENCES

10. Röntgen W C (1895) Über Eine neue Art von Strahlen. Sitzber. Würzburger Phys. Med. Ges. 9:132–141
11. Barkla C G (1916) XXXII. Note on experiments to detect refraction of X-rays. Phil. Mag., 31(184):257–260
12. Ingal V N, Beliaevskaya E A, Efanov V P (1991) Russian patent no. 2012872. (1992) Method for obtaining the image of the internal structure of an object. USA Patent no. 5319694
13. Ingal V N, Beliaevskaya E A (1995) X-ray plane-wave topography observation of the phase contrast from non-crystalline objects. J. Physics D: Appl. Phys. 28(11):2314–2317
14. Takeda T, Momose A, Itai Y, Wu J, Hirano K (1995) Phase-contrast imaging with synchrotron x-rays for detecting cancer lesions. Acad. Radiol. 2(9):799–803
15. Ingal V N, Beliaevskaya E A (1996) Phase dispersion radiography of biological objects. Physica Medica XII(2), 75–81
16. Ingal V N, Beliaevskaya E A (1997) Imaging of biological objects in the plane-wave diffraction scheme. Il Nuovo Cimento D 19(2-4):553–560
17. Bonse, U, Hart, M (1966) An X-ray interferometer with Bragg case beam splitting and beam recombination. Z. Physik 194(1):1–17
18. Snigirev A, Snigireva I, Kohn V, Kuznetsov S, Schelokov I (1995) On the possibilities of x-ray phase contrast microimaging by coherent high-energy synchrotron radiation. Rev. Sci. Instrum. 66(12):5486–5492
19. Paganin D, Mayo S C, Gureyev T E, Miller P R, Wilkins S W (2002) Simultaneous phase and amplitude extraction from a single defocused image of a homogeneous object. J. Microsc. 206:33–40.
20. Wilkins S W, Gureyev T E, Gao D, Pogany A, Stevenson A W (1996) Phase-contrast imaging using polychromatic hard X-rays. Nature 384: 335–338
21. Weitkamp T, Haas D, Wegrzynek D, Rack A (2011) ANKAphase: software for single-distance phase retrieval from inline X-ray phase-contrasts radiographs. J. Syncrotron Rad. 18:617–629. Erratum: 20:205
22. Ghani M U, Wong M D, Wu D, Zheng B, Fajardo L L, Yan A, Fuh J, Wu X, Liu H (2017) Detectability comparison between a high energy x-ray phase sensitive and mammography systems in imaging phantoms with varying glandular-adipose ratios. Phys. Med. Biol. 62:3523–3538
23. Castriconi R, Mettivier G, Russo P (2016) Image Quality and Radiation Dose in Propagation Based Phase Contrast Mammography with a Microfocus X-ray Tube: A Phantom Study**.** In: Tingberg A., Lång K., Timberg P. (eds) Breast Imaging. IWDM 2016. Lecture Notes in Computer Science, vol 9699. Springer, Cham. pp. 618–624
24. Wu X, Liu H (2003) Clinical implementation of x-ray phase-contrast imaging: theoretical foundations and design considerations. Med. Phys. 30:2169–2179
25. Momose A, Yashiro W, Kido K, Kiyohara J, Makifuchi C, Ito T, Nagatsuka S, Honda C, Noda D, Hattori T, Endo T, Nagashima M, Tanaka J (2014) X-ray phase imaging: from synchrotron to hospital. Phil. Trans. R. Soc. A 372:20130023
26. Thuering T, Stampanoni M (2014) Performance and optimization of X-ray grating interferometry. Phil. Trans. R. Soc. A 372:20130027
27. Weitkamp T, Diaz A, David C, Pfeiffer F, Stampanoni M, Cloetens P, Ziegler E (2005) X-ray phase imaging with a grating interferometer. Opt. Express 13(16):6296–6304
28. Diemoz P C, Vittoria F A, Hagen C K, Endrizzi M, Coan P, Bravin A, Wagner U H, Rau C, Robinson I K, Olivo A (2016) A single-image retrieval method for edge illumination phase-contrast imaging: Application and noise analysis. Phys. Med. 32(12):1759–1764
29. Capano V (2010) Phase contrast radiography. B.Sc. thesis, Department of Physics, University of Naples “Federico II”, Naples, Italy (In Italian).
30. Frallicciardi P M (2009) Single photon counting X-ray micro imaging of biological samples. PhD thesis, University of Naples “Federico II”, Naples, Italy.

Contacts of the corresponding author:

Author: Prof. Paolo Russo
Institute: Università di Napoli Federico II, Dipartimento di Fisica “Ettore Pancini”
Street: Via Cintia
City: Napoli
Country: Italy
Email: paolo.russo@na.infn.it

MEDICAL PHYSICS EDUCATION AND SCOPE FOR IMPROVEMENT

Prof. Arun Chougule
Chair, ETC-IOMP [Elect]
arunchougule11@gmail.com

INTRODUCTION

Medical physics is a branch of applied physics, pursued by medical physicists, who use physics principles, methods and techniques in practice, in the clinical environment and in research, for the prevention, diagnosis and treatment of human diseases with the specific goal of improving human health and well-being [1].It encompasses radiation oncology physics, medical health physics, imaging and nuclear medicine physics. Medical Physicists are also involved in research, development and teaching. The job of medical physicists is multidisciplinary involving wellbeing of patient as well as general public in context of radiation safety.

Medical physics is a fast growing area needing high degree of knowledge and professional competency due to the rise in complexity of treatment procedures, increasing access to medical technology and the requirement of coordination between medicine, physics and biomedical engineering areas. The unprecedented surge in medical physics competency in the last 2- 3 decades is due to implementation of specialized physics intensive procedures such as particle therapy, image guided & intra operative radiotherapy ,advanced imaging and nuclear medicine techniques. In this scenario to handle this new technology era the quantity of qualified medical physicist needs to be in consonance with the competency needed. There is a special requirement for education and training of medical physicists which lead to opening of numerous educational programme around the world.

DEFINING MEDICAL PHYSICISTS

According to the definition of the International Basic Safety Standards (BSS) [2], a medical physicist working in a clinical environment is: "*a health professional, with specialist education and training in the concepts and techniques of applying physics in medicine, and competent to practise independently in one or more of the subfields (specialties) of medical physics*."

Further IOMP has defines medical physics profession [3] as "*Medical Physics is a branch of Applied Physics, pursued by medical physicists, that uses physics principles, methods and techniques in practice and research for the prevention, diagnosis and treatment of human diseases with a specific goal of improving human health and well-being*"

Looking to needs and to maintain minimum standards in medical physics education across the globe, IAEA has published their updated suggestions related to roles, responsibilities, education and training requirements for clinically qualified medical physicists [3].The goal of the publication is to establish criteria that support the harmonization of education and clinical training worldwide, as well as to promote the recognition and professionalism of medical physics as a profession internationally. It suggests that after receiving the proper under graduate program in physical or engineering services, the medical physicist students should undergo 1-3 years of academic education of post graduate level and also recommends the academic training at the postgraduate level which must be followed by at least two additional years of structured practical training in a clinical environment, in one or more specialties of medical physics. Overall, the academic education and clinical training should extend over a minimum period of, typically, seven years.

It suggests that medical physics programme should be recognized by an international or national accreditation body in order to enhance their independent work ability and their professional competence. Further Medical physics is not a static field and it's rapidly growing, changing as a dynamic scientific profession and therefore to keep updated the practicing medical physicists should undergo continuous professional development [CPD] by organizing and participating in the workshops, symposium, national & international conferences and also they should be regularly updated by consulting relevant scientific journals and literature.

In addition, the Task Group reports by American Association of physicists in medicine has continuously published reports on essential and guidelines for hospital based medical physics residency training programs [4][5][6] since 1990.The first AAPM report (No-36) on essential and guidelines for hospital based medical physics residency training program was published on 1990 [4]. The residency programs was aimed, both educating and providing practical experience so that an individual would be ready to be examined for certification and practice in a hospital setting. They are conceptually different than the academic programs and post-doctoral fellowships, where the aim is primarily research. Following that in 1993, AAPM report (No-44) on academic program for Master of Science degree in medical physics was published in 1993 [7]. This committee has collected a set of topics that provides the minimum level of training an M.S. graduate would be expected to have. This report was further revised in 2002, 2009 [8] [9] which concentrated on the clinical and professional knowledge needed to function independently as a practicing medical physicist in the areas of radiation oncology, diagnostic imaging, and nuclear medicine.

In 2008, AAPM Task Group 133 published the report "Alternative Clinical Training Pathways for Medical Physicists [10]. The focus of this report was to describe different training pathways to achieve clinical competency and to outline potential mechanisms for the creation of a suitable number of clinical residency positions. In doing so, this report introduced two initiatives that would become accredited alternative training procedures: a professional degree, the Doctorate in Medical Physics (DMP), which contains both didactic and clinical training, and the certificate program, which provides core didactic elements of a graduate degree in medical physics for students with a PhD from a related field. The first certificate program was accredited by CAMPEP in 2011, and as of March 2017 there were 24 such programs. This latest report recommends structure and conduct of medical physics program. Following the appropriate didactic training, a clinical training period of at least two years is required. The first goal in these two years should be to provide the trainee with a broad experience in clinical medical physics in the subfield in which the residency program specializes. This provides the foundation for the physicist to manage the broad range of medical physics tasks involved in caring for patients in diagnostic and interventional radiology, nuclear medicine, or radiation oncology. Next, training should build on this clinical foundation in terms of both level of responsibility and coverage of topics such as specification, commissioning and acceptance testing, quality assurance, special procedures, and patient safety measures. After two years of clinical training, residents are expected to have sufficient competence to function independently and safely as medical physicists in a clinical environment. Some residency programs may choose to require more than two years of training, allowing residents time to obtain further supervised experience. It is important to note that portions of clinical training may take place at affiliated institutions. They also recommended essential medical physics didactic elements for physicists entering through an alternate pathway.

ACCREDITATION OF MEDICAL PHYSICS PROGRAMME

In addition, the American Association of Physicists in Medicine (AAPM) have a well-recognized system for accreditation of residency programs in Medical Physics, the Commission on Accreditation of Medical Physics Education Programs, CAMPEP [11] and recently created a Memorandum of Understanding (MOU) with other institutions to promote the unification and harmonization of certification programs of these professionals. The International Medical Physics Certification Board (IMPCB) was created by IOMP to provide guidance and support to medical physics organizations across the globe for the establishment of national medical physics certification boards and to conduct board examinations for certifying medical physicists [12]. IOMP collaborates with IMPCB providing international accreditation for MSc courses and other educational/training activities (initiated in 2016).

PROGRAMME FOR ENHANCEMENT OF MEDICAL PHYSICS CURRICULUM

In European Community, for several decades, medical physics teachers and researchers worked for producing teaching materials compatible with the different training areas in Medical Physics. The EMERALD and EMIT educational programs are good examples (Tabakov, 2008) [13]. Tabakov also mentioned that to fulfill the educational requirement for profession within two year of post-graduation, students should be specialized in one field. (e.g. Radiotherapy) ,which will educate the students very well in one sub specialty. But it may impact the overall medical physics knowledge and employment opportunity in different fields. Such initiatives demonstrate the intense effort that the international community has been doing to ensure the qualification of these professionals at a high quality education level. It must also be emphasize that the recently WHO/IAEA proposed "Bonn: Call for Actions" document [14] [15], which establish a proposal for priorities for stakeholders regarding radiation protection in medicine for the next decade, present the "strengthen radiation protection education and training of health professionals" in the Action 4[14] [15]. Some universities already open under-graduate (BSc) courses on medical physics in order to accommodate the increased volume of professional knowledge. As all other recommendations, the IOMP Model Curriculum refers to the level of education as a post-graduate (MSc) type education – a typical pattern followed almost everywhere. Recently a new MSc Curriculum was introduced in the UK National Health System (NHS) requiring the MSc-education in a specific sub-field of Medical Physics to be tripled – e.g. Radiotherapy Physics to be expanded from 15 credits to 45 credits. The same requirements were placed to the education of the sub-specialties of Radiation Safety, Imaging with Ionizing Radiation and Imaging with Non-ionizing Radiation. The problem of including the large volume of Medical Physics education into a limited number of Post-graduate contact hours needs special discussion by the whole profession. One possible outcome is opening of Under-graduate (BSc-level) Education in Medical Physics.

CURRENT STATUS

Medical physicists working as health professionals shall demonstrate competency in their discipline by obtaining the appropriate educational qualification and clinical competency training in one or more subfields of medical physics. The current requirements for the qualification of medical physicists vary largely throughout the world. This variation has recently been confirmed by the results of two large scale surveys undertaken by the EFOMP in 2006 [16] and the IAEA in 2010–2011, which together included responses from 77 countries from five continents. The minimum 'academic education and clinical training' time frame for employment as a medical physicist at a hospital varies between three to nine years, the average being about six years. The requirements for the fraction of time spent in basic, postgraduate and clinical training varies enormously, ranging from a basic three year degree without any clinical training to nine years including all three components. Basic physics studies of approximately four years are the most common modality for over 90% of the respondents, and for countries with a postgraduate system, one or two year programmes are most frequent. The largest discrepancy found in the analysis corresponds to the clinical training programmes across different countries. Their duration varies from non-existent to a four year requirement. They also have rather different formats; for example, among the formally structured programmes, 20% have a residency system or on the job training for the first year, 29% have it as a component of the postgraduate programmes and 51% do not have structured clinical training. The assessment of the skills acquired during the clinical training also shows rather different patterns, ranging from a formal examination (57%) to continuous assessment (9%) or a combination of the two (23%); 11% of the responses were unspecified. It is worth noting that a significant number of countries having formal clinical training have their trainees remunerated as staff members, and that some countries have their trainees employed automatically upon completion of the training programmes , whereas others do not guarantee employment.

To cater to the ever increasing need and easy affordable access to the educational material in the field of medical physics development and availability e-learning material has already found its presence in the field of medical engineering and physics. At present large number of e learning programmes are available such as the AAPM virtual library, the IAEA training materials and website, the EMERALD and EMIT to upgrade the medical physics knowledge

MEDICAL PHYSICS COURSE IN INDIAN SCENARIO

As a case study I will explain the growth of Medical Physics education in India. In India, two different types of medical physics courses are conducted, namely (a) Post Master of Science (M. Sc.) Diploma in Radiological / Medical Physics (Post M. Sc. Dip RP/Dip MP), and (b) M. Sc. Degree in Medical Physics (M. Sc. [Medical Physics]). In Post M. Sc. Dip RP/Dip MP course, the entry level qualification of the candidate is M. Sc. Degree in Physics whereas in M. Sc. (Medical Physics) course the entry level qualification is Bachelor of Science Degree majoring in physics. As the majority of the medical physicists trained in India work in the discipline of radiation oncology medical physics (ROMP), the entry level qualifications are based on the eligibility criteria prescribed by the Atomic Energy Regulatory Board (AERB) for medical physicist and radiological safety officer (RSO)[17]. The curriculum of the Post M. Sc. Dip RP course, conducted by Bhabha Atomic Research Centre (BARC) since 1962, has been adopted by the AERB indicating it to be one of the best courses in the country with its well organized modality. In the recent past, over 24 universities/institutions have started either Post M. Sc. DipRP / DipMP or M. Sc. (Medical Physics) courses to cater to increasing demand for medical physicists.

At present, more than 200 medical physicists are graduating per annum from the education and training programs conducted at different universities/institutions in India.

INTERNSHIP COURSE - A MANDATORY FOR QUALIFYING MEDICAL PHYSICS

As per revised AERB safety code minimum 12 months internship in a recognized well-equipped radiation therapy department has been specified as a mandatory requirement for a qualified Medical Physicist and Radiological Safety Officer. To fulfil this requirement, all the Medical Physics students passing out from different academic courses in the country need to undergo one year internship/residency under the supervision of a qualified and sufficiently experienced Medical Physicist at a recognized well-equipped radiotherapy centers in the country.

REFERENCES

1. International Atomic Energy Agency. Roles and responsibilities, and education and training requirements for clinically qualified medical physicists. Vienna: IAEA; 2013. (IAEA Human Health Series n° 25)

2. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards General Safety Requirements Part 3: INTERNATIONAL ATOMIC ENERGY AGENCY VIENNA ISBN 978–92 –0–135310–8 ISSN 1020–525X No. GSR Part 3
3. International Organization for Medical Physics, The Medical Physicist: Role and Responsibilities, Policy Statement No. 1, IOMP, http://www.iomp.org
4. AAPM. Essentials and guidelines for hospital-based medical physics residency training programs. AAPM Report No. 36; 1990.Available from: www.aapm.org /pubs/reports_36.pdf
5. AAPM. Essentials and guidelines for hospital-based medical physics residency training programs. AAPM Report No. 90; 2006. Available from: www.aapm.org /pubs/reports_90.pdf
6. AAPM. Essentials and guidelines for clinical medical physics residency training programs. AAPM Report No. 249; 2013. Available from: http://www.aapm.org /pubs/reports/RPT_249.pdf
7. AAPM. Academic program for Master of Science degree in medical physics. AAPM Report No.44; 1993: Available from: http://www.aapm.org/pubs/reports/RPT_44.pdf
8. AAPM. Academic program recommendations for graduate degrees in medical physics. AAPM Report No.79; 2002: Available from: http://www.aapm. org/pubs/reports/RPT_79.pdf
9. AAPM. Academic program recommendations for graduate degrees in medical physics. AAPM Report No.197; 2009: Available from: http://www.aapm. org/pubs/reports/RPT_197.pdf
10. AAPM. Alternative clinical training pathways for medical physicists. AAPM Task Group Report 133; 2008. Available from: http://www.aapm. org/pubs/reports_133.pdf
11. CAMPEP. the Commission on Accreditation of Medical Physics Education Programs;2017 http://www. campep.org/campepp&ps.pdf
12. IMPCB. The International Medical Physics Certification Board. 2010; http://www.impcbdb.org
13. Tabakov S .e-Learning development in medical physics and engineering; Biomed Imaging Interv J 2008; 4(1):e27
14. IAEA and WHO (2012). "Bonn Call-for-Action". Joint Position Statement by the IAEA and WHO. Vienna, 2012
15. IAEA and WHO .BONN CALL FOR ACTION 10 Actions to Improve Radiation Protection in Medicine in the Next Decade. https://www.iaea.org/sites/default/files/17/12/bonn-call-for-action.pdf
16. Eudaldo T, Olsen K. The present status of medical physics education and training in Europe: an EFOMP survey. Phys Med. 2008 Mar; 24(1):3-20. Epub 2007 Dec 3
17. AERB. Medical Physicist Courses in India. AERB RSD.2018. https://www.aerb.gov.in/images/PDF/Radiotheraphy/rsd4feb2018.pdf
18. Tabakov S. Medical physics education after the isco listing of the profession – quo vadis? European Medical Physics and Engineering Conference, Sofia, October 18-20, 2012
19. B Loughery , G Starkschall, K Hendrickson, J Prisciandaro et al.Navigating the medical physics education and training landscape. J Appl Clin Med Phys 2017; 18:6: 275–287.

MY JOURNEY TO MEDICAL PHYSICS

I . Duhaini[1]

[1] Radiation Oncology Department, Rafik Hariri University Hospital, Beirut, Lebanon

Abstract— **many people, including me, wonder how physics and its theories apply to our daily life. I have never thought that I will be using physics in my profession until I had meet the Director of Medical Physics Program at Wayne State University at that time, Dr. Colin Orton, who introduced me to Medical Physics.**

Keywords— **Medical Physics, Education and Training, Radiation Therapy.**

I. INTRODUCTION

The first day statement of my high school physics teacher was: *"You can find physics in all aspects in our life"*. Of course everybody in class laughed out loud and each one of us started challenging the teacher with many things in our life we thought had nothing to do with physics. The confident teacher will answer all inquiries and questions and trace it back to physical phenomena. That was the astonishing moment where all students started to like the class and wait eagerly to discover and learn about physics and its application in our life.

II. SCHOOL DAYS

During my intermediate school days, back in 1980's, my dad assigned me to teach my younger brother physics subject because he didn't like to study it at all, arguing about the need of physics in our life, in which I did not have an answer for that. I was so intense and I used to treat him very badly even punching him with pencils on his hands because he refused to do homework. My younger brother ended up hating physics and schools in general and he was the only one out of five other brothers who did not have a university degree. I felt and till now guilty because I misused teaching physics in the wrong way.

When I was in high school, my friends used to come over our house to teach them physics and math; it gave me a respectful image among my friends unlike my competitor in class who used to have his knowledge for himself and never shared it with anybody, so the class used to look at him inferiorly. I then realized the value of sharing information and teaching it.

I finished my BS degree in Biology at the American University of Beirut (AUB) in 1995; I decided to continue perusing a Teaching Diploma degree for the sake of teaching career in physics. While I was still doing on-class observation and training in 9th Grade Physics Class at the American Community School (ASC), I had an opportunity to take over the class since the home teacher had a break-down and she quit from teaching due to students' behavior in the class. I remembered my mistakes with my younger brother; change the gear of teaching Physics, make it fun and interesting! I continued teaching in this class and students' behavior has changed; **"we never thought Physics is fun until you taught us"**; a goodbye note from the class at the end of the year.

III. JOURNY TO THE USA

My parents encouraged me to join a medical school and to become a physician like my eldest brother, however, medicine was not fully my interest. In 1996, I moved to the States, and by coincidence while continuing a post degree in Industrial Engineering at Wayne State University (WSU) in Michigan, USA, I meet an AUB physics Graduate who introduced me to a new profession called **Medical Physicist**. The term made me enthusiastic and eager to find out more about this profession. Fortunately, WSU offers this program at the medical school. So, I contacted the head of the department **Dr. Colin Orton** and he showed me what a medical physics does as a profession and how to apply the principles of radiation physics in the diagnosis and treatment of cancer patients. So, I decided to transfer to this program instead. Eighteen years later, I am still happy I saw one of AUBits physics guy who changed my career life.

I have joined the master program in Medical Physics which above the clinical and technical duties, there are teaching and training duties assigned to this profession and that was the reason I choose it. An essential part of my career is teaching and training technologists, nurses, physicians and other professions about the good use of radiation in diagnosis and treatment of diseases and guide them on the ways to protect them from the risks of radiation exposures. Upon completion of my degree and residency, I have worked in three hospitals consequently till 2004.

When I came back to Lebanon in 2004, establishing the Radiation Oncology Department at Rafik Hariri University Hospital, I had difficulties finding Radiotherapy Technologists, thus I hired Radiology Technologists and I had to teach and train the staff on a daily basis until they become professional in their duties. In 2013, I suggested to the Faculty of Medicine at the Lebanese University in Saida to incorporate a couple courses of Radiotherapy Physics Principles and Radiotherapy Treatment Application Courses in the Radiologic Technological BS Degree to fill the gap in this degree especially that there are 11 Radiotherapy Centers in Lebanon and there is a high demand for these technologists to have the proper education and training before treating cancer patients. The program started in 2014 and many of my students are finding Radiotherapy jobs easy and worth it.

I learned that medical physics is not only a profession to work in a hospital or to teach at a university, it is a way of seeing and experiencing life. *“ We do not teach you only how to use radiation in diagnosis or treatment of cancer, we also teach you to be the problem solvers in anything you encounter in your life”;* Professor **Colin Orton**, my advisor and the head of Medical Physics Department at WSU. And this is what physics really is; my secretary always calls me to fix her printer or copier machine before calling in services, she knows that I always fix it long before they showed up.

IV. CONCLUSIONS

Now, that I am involved with the International Organization of Medical Physics (www.iomp.org) and recently I was elected as a member of the ExCom and as the Treasurer, I am eager to establish a Master Program in Medical Physics in Lebanon so that to be the top in the region. We have now many skilled and the experienced Medical Physicists here and abroad to run the program. Holding the President of the Middle East Federations of Organizations of Medical Physics (www.mefomop.org) for two terms from 2009 till 2015, many students from our Arab Countries are seeking to pursue a postgraduate degree in medical physics, and I am hoping to channel them to this new Medical Physics Program in Lebanon.

ACKNOWLEDGMENT

I would like to thank Prof. Colin Orton for his encouragement to join his MP program back in 1996 at WSU. Also, I would like to thank Prof. Slavik Tabakov for his invitation to write about my Journey to Medical Physics so that to shine a light for students who are looking to pursue a Medical Physics career in their life. .

Contacts of the corresponding author:

Author: Ibrahim Duhaini, BS,TD,MS,FIOMP
Position: Chief Medical Physics and RSO
Department: Radiation Oncology Department
Institute: Rafik Hariri University Hospital
Street: BGUH Street
City: Beirut
Country: Lebanon
Email: Duhaini@yahoo.com

KWAN HOONG NG AWARDED THE MARIE SKLODOWSKA-CURIE AWARD OF IOMP, 2018

The Marie Sklodowska-Curie Award is one of the highest awards given by the International Organization for Medical Physics. It was established to honour scientists who have distinguished themselves by their contributions to education and training, advancement of medical physics knowledge based upon independent original research and/or advancement of the medical physics profession.

Dr Ng is a Professor at the Department of Biomedical Imaging, University of Malaya, Kuala Lumpur, Malaysia. His journey in academia began when he received his M.Sc. (Medical Physics) from the University of Aberdeen and Ph.D. (Medical Physics) from the University of Malaya (1995). He is certified by the American Board of Medical Physics (1999). He is a Fellow of the Institute of Physics, UK (IoP) (2008), the International Organization for Medical Physics (IOMP) (2013), and the Academy of Sciences Malaysia (2014). He is also a member of the Academy of Medicine Malaysia (2003).

While a visiting scientist at the University of Wisconsin, Madison (1995-97) Dr Ng had the opportunity to work with great physicists such as the late Prof. John Cameron who was the inventor of bone densitometry and thermoluminescent dosimetry. His visit resulted in many fruitful collaborations and lasting friendship.

Dr Ng established and headed up the Master of Medical Physics Programme, University of Malaya in 1998, providing an opportunity for those who shared his passion to study locally in S E Asia and launch their professional careers. More than 120 students, from both Malaysia and overseas, have graduated from this programme. In 2002, he was responsible for obtaining the UK's Institute of Physics and Engineering in Medicine (IPEM) accreditation for the Master of Medical Physics programme, which currently is the only programme so accredited outside the British Isles. Dr Ng has also contributed greatly to the teaching and training of radiology and clinical oncology residents.

Dr Ng has contributed extensively to the IOMP for over two decades: having served as member in several committees; chairman, International Advisory Board (2003-2006); and chairman, Publication Committee (2003-2006). In 2013 the IOMP honoured him as one of the top 50 medical physicists for outstanding contributions to the field. In 2016 he received the International Day of Medical Physics (IDMP) Award.

Dr Ng is renowned for his breast density research and its clinical applications in predicting breast cancer. His other research contributions are in breast imaging, radiological protection, radiation dosimetry and medical physics education. He has long time collaborated with Prof. Lai Meng Looi and Prof. David Bradley on physical characterization of breast tissues since his PhD. He is actively collaborating with Dr Ray Kemp on risk communication and public understanding of radiation; Dr U Rajendra Acharya on image processing, artificial intelligence and radiomics; and Prof. Wilfred Peh on radiology and scientific publishing.

Dr Ng has authored/coauthored more than 230 peer-reviewed journal papers, 80 conference papers, 30 book chapters and co-edited seven books. He has presented more than 550 scientific papers, with over 300 of them being invited lectures. He is a member of the editorial and advisory board of more than 12 journals, and has served as one of the series editors for the “Series on Medical Physics and Biomedical Engineering” published by Taylor and Francis for over ten years.

Dr Ng has held several visiting professorships, such as Jinan University, China; Chang Gung University, Taiwan; Chulalongkorn University, Thailand; University of Sydney, Australia; and most recently at the University of São Paolo, Brazil.

As a consultant and expert with the International Atomic Energy Agency (IAEA), he has participated in numerous expert missions, conference lectures, and in drafting and reviewing standards, guidelines, chapters and reports. Some notable contributions are: “Diagnostic Radiology Physics - A Handbook for Teachers and Students”, “Clinical Training of Clinical Medical Physicists Specializing in Diagnostic Radiology”, “The Fukushima Daiichi Accident”, and “Advanced Medical Physics Learning Environment”.

Dr Ng was a member of the International Advisory Committee on EMF of the World Health Organization. He has also served as a consulting expert for the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

On the regional scene, Dr Ng is the Founding President of the South East Asian Federation of Organizations for Medical Physics (SEAFOMP), serving from 2000-06 before being appointed as the President Emeritus in 2014. He instituted the celebrated John Cameron Memorial Lecture. Further, he became one of the founding members of the Asia Oceania Federation of Organizations for Medical Physics (AFOMP), serving as its President from 2010-12. In 2014, he founded the ASEAN College of Medical Physics, which conducts regular medical physics education and training workshops.

In 2017, he started an international leadership and mentoring programme for medical physicists, collaborating with Prof. Robert Jeraj, Prof. Tomas Kron and Prof. Eva Bezak as fellow mentors. Those being mentored come from Brazil, Cambodia, Hong Kong, Indonesia, Japan, Malaysia. Peru and Vietnam.

Throughout his career, in addition to his contributions through basic research, Dr Ng has been a passionate educator and communicator in a field which many would otherwise approach with trepidation. He has particularly sought to build skills and capacity in South East Asia and developing nations. Away from his busy scientific and professional commitments, Dr Ng and his wife Suan devote much time in church activities and related charitable work.

Dr Kwan Hoong Ng C.V. is available at https://umexpert.um.edu.my/ngkh

Professor Dr Anchali Krisanachinda

ELISEO VAÑO AWARDED THE IUPESM AWARD OF MERIT, 2018

Professor Eliseo Vano: A dear friend, a mentor, a person to derive motivation from

I had the pleasure of meeting Professor Eliseo Vano in 2001 in the First International Conference on Radiation Protection of Patients held at Malaga, Spain, even though I had been reading his publications in the area of medical radiation protection. I must say Eliseo is a doyen of medical radiation protection with unparalleled similarity in contributions the world over. He has a knack of picking up the problems that one faces in day-to-day practice, investigating them scientifically and publishing the data generated for the benefit of professionals all over the world. There has been a tendency among many medical physicists to confine to work that involves working alone or among medical physics colleagues as it is hard to work together with radiologists and clinical colleagues. Cooperative efforts have their own level of complexity and require a skill of “being useful to others” which Eliseo has mastered. Most of his publications prove how successful he has been in achieving the collaboration with clinical colleagues like cardiologists, electrophysiologists, orthopedic surgeons, urologists, just to name a few. I wonder if he had not taken the lead in working with clinical colleagues and producing excellent research papers, things would not have been the same in the world as we have today. He is the person behind many actions in medical radiation protection that are common today.

The amount of outputs achieved by him and response time to communication indicate that he hardly sleeps few hours. Just send him an email at midnight or early morning and you can be assured of his response right immediately. The number of travels he makes is more than anyone amongst us and yet his efficiency is unbeatable. I have no hesitation in accepting that he is role model and I have loved to derive motivation from him and taking him as my role model.

I joined the International Atomic Energy Agency (IAEA) in late 2001 and during my 11+ years of work at the IAEA I felt that Professor Vano (I will refer to him as Eliseo, being such a good friend) is the best expert in every project or action that I initiated in fluoroscopic guided interventional procedures, digital imaging, education and training, regulatory framework, radiation and cataract and the list can go on. It was his preoccupation and non-availability that prevented me to utilize his services in some, much as I tried in to have him in every case. He is an excellent contributor in meetings and his comments are practical and pragmatic. When we were driving the radiation protection actions almost exclusively towards patient protection, I found in him a champion of occupational protection. He has been Chair of the Working Party MED of Article 31 of European Commission for several years and has contributed actively to the revision of European Basic Safety Standards.

He was appointed as Chair of the Committee 3 of the International Commission on Radiological Protection (ICRP) in 2009 and he asked me act as Secretary of the Committee. I had the pleasure of working actively for 8 years with him and enjoyed his cooperative spirit besides professional excellence.

He has been advisor to the Spanish Ministry of Health for radiation protection in medical exposures.

Eliseo has been nominated by the Spanish Ministry of Health as an expert to represent Spain on several International Committees, such as IAEA, WHO and UNSCEAR.

Wonder if there is anyone in the world who has published as much as Eliseo in the area of medical radiation protection.

I salute Eliseo on his commendable success and we in IOMP and IUPESM family are proud of his achievements.

Madan M. Rehani, PhD
Vice President, IOMP
Massachusetts General Hospital, Harvard Medical School, Boston, USA

ANCHALI KRISANACHINDA AWARDED THE HAROLD JOHNS MEDAL, 2018

In recognition of her exceptional achievements in international education and training in medical physics and outstanding contributions in promoting international development of the medical physics profession, the IOMP has awarded Professor Anchali Krisanachinda the Harold Johns Medal, one of the highest honours of the Organization.

Professor Anchali Krisanachinda is from the Department of Radiology, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand.

Professor Krisanachinda has been very much involved in promoting the development of medical physics in Asia, particularly in the South East Asian Countries. She was one of the Founding Officers of AFOMP and SEAFOMP. She was elected AFOMP Treasurer in year 2000 and was elected SEAFOMP Vice President in 2001 and became President in 2005. Under her leadership, Thailand hosted the first AFOMP congress, the 1st AOCMP in conjunction with the 2nd SEACOMP in Bangkok in 2001 and the 9th AOCMP in conjunction with the 7th SEACOMP in Chiang Mai in 2009. She was the congress chairperson of these major Asian international medical physics congresses. She also organized and chaired the 22nd IOMP International Conference of Medical Physics (ICMP) in Bangkok in 2016. In her own personal capacity as well as her official capacity of AFOMP and SEAFOMP, Professor Krisanachinda has helped medical physicists in Brunei, Cambodia, Laos, Myanmar and Vietnam in establishing their own national medical physics organizations and contributed to the development of medical physics in these countries.

Professor Krisanachinda has been serving as IAEA National Project Coordinator for Thailand under the Regional Cooperative Agreement (RCA) for the Asian Region (RAS) and has completed several projects since 1985. The projects included IAEA programmes in QA/QC, DAT and DATOL (Distance Assisted Training On Line) in nuclear medicine, and Strengthening Medical Physics through Education and Training in Asia and Pacific where a structured clinical training programme for medical physicists was initiated in Thailand. This was an IAEA residency training programme (initially started as a pilot programme in 2007 and now a regular one) for medical physicists practicing in diagnostic radiology medical physics, radiation oncology medical physics and nuclear medicine medical physics in Thailand and was organized under Thai Medical Physicist Society and Chualalongkorn University. Professor Krisanachinda has been a principal investigator of the IAEA Coordinated Research Project on Quantitative PET/CT, SPECT/CT since 2008. She has also been appointed as IAEA expert and consultant in the field of nuclear medicine and medical physics since 2005 and has taken a number of IAEA missions to a number of South East Asian countries.

In recognition of her achievements in global development of medical physics and her outstanding contributions to the services and activities of IOMP, AFOMP, SEACOMP and the IAEA, Professor Krisanachinda was named as one of the Fifty Outstanding Medical Physicists for the Past 50 Years at ICMP 2013 held in Brighton, UK. At the World Congress in Toronto, 2015 Prof. Anchali Krisanachinda was made Fellow of IOMP.

Let us congratulate Professor Krisanachinda for her outstanding achievements and her award of the Harold Johns Medal 2018. She truly deserves the honour.

Kin Yin Cheung, PhD
Past IOMP President and IUPESM President

SALLY HAWKING – HONORARY MEMBER INTERNATIONAL ORGANIZATION FOR MEDICAL PHYSICS (2018)

I met Mrs Sally Hawking in early 2012, when I was still IOMP Treasurer, since this time she has been one of the most dedicated members of the IOMP team, caring for many of our administrative and finance activities. Currently Mrs Sally Hawking is External and International Services Manager in IPEM, UK specifically dealing with the activities of IOMP.

Sally has graduated Communication and Media Studies at Sheffield Hallam University, UK and further specialised Project Management. She joined the UK Institute of Physics and Engineering in Medicine (IPEM) in 2012. Since this time she works as Administrative Secretary of IOMP. In this period of time she also supported the work of EFOMP and IUPESM. Her activities for these 6 years were outstanding. She not only delivered an exceptional service of Administrative Secretary, helping directly the Treasurer, the Secretary General, the President, and all ExCom, taking also active role in some vital moments for the development of the Organisation.

Sally arranged the electronic banking of IOMP and all tax-related issues of the Organisation. Most importantly she took a very active role in the incorporation of IOMP. Mrs Sally Hawking, Prof. Stephen Keevil and myself worked several years on this very important, but also very difficult task, which led to the establishment of the legal status of IOMP. As lead of the Work Group dealing with the IOMP incorporation, I witnessed Sally’s very diplomatic role in dealing with the Law and Finances Firms, which were moving our case through the quite unknown process of incorporating of an international organisation. The results achieved last year are a milestone for IOMP – arranging our status as a legal body; strengthening the international position of IOMP; supporting its status as NGO to WHO; potentially opening ways for external project funding, etc. The legal and business hand of IOMP – the IOMP Company was registered in the UK at the end of December 2017 and started its activities in January 2018. Just in the first month of its incorporation, IOMP was already benefitting from this action – re-confirming its NGO status with WHO.

Alongside the many administrative and financial activities in IOMP, Sally took also an active role in the work of the IOMP Finance Sub-Committee, IOMP Women Sub-Committee, IOMP Web Sub-Committee. Her professional, constructive and gentle way of dealing with urgent situations, and also with everyday tasks, was of great help to our IOMP ExCom members, volunteering their time for the global development of medical physics. The impact of Sally in IOMP is a real example of the important inter-professional skills, necessary for our profession.

The activities of Mrs Sally Hawking in the IOMP were far above the work of an Administrative Secretary. In her diplomatic and highly competent way of work, she played pivotal role in some of the most important organisational aspects of IOMP, thus making significant contributions to the objectives of IOMP and indirectly helping thousands of medical physicists. I was very happy that the IOMP Awards and Honours Committee, headed by Dr Simone Kodlulovich-Renha unanimously approved Mrs Sally Hawking as IOMP Honorary Member - the special IOMP Honour, recognising significant contributions to the objectives of IOMP by persons who are not Medical Physicists.

I am very grateful to Mrs Hawking for her relentless help in the activities of IOMP and its incorporation. On behalf of the IOMP Executive Committee, I am happy to sincerely congratulate her for this well-deserved Honour.

Prof. Slavik Tabakov, President IOMP

Mrs Sally Hawking with the IPEM CEO Rosemary Cook, CBE and the Presidents of IOMP and IPEM (S Tabakov and M Tooley) at the installation of the IOMP Company Registration Plaque, IPEM, York, April, 2018