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**Report and Recommendations on Available Multimedia Material for Solid State,
Nuclear and Particle Physics**

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1. Introduction and Background

Multimedia resources have been used for the teaching and learning of all areas of physics for many years. Educators and researchers around the world are developing these tools, including simulations of physical systems, virtual laboratories, videos of real and animated experiments, and online tutorials. Many publishers include this type of material as supplements to their textbooks. There are commercial enterprises where multimedia educational material is their sole product.

One of the challenges that many physics teachers face is to find suitable multimedia material. Indeed, the large numbers of products that are available on the Internet make it very time consuming for teachers to search for such products and to select those that are relevant and of high quality.

This review is the sixth annual review by an international group of physicists. The primary goal of this continuing effort is to identify multimedia resources that have the potential to significantly improve physics learning. Each year a broad topic is selected, a search for existing resources is made, and the high quality items are identified through peer review. This year the modern physics topics of Solid State and Particle physics were chosen as topics for the review.

The reports of the review results have been presented at MPTL workshops since 2002. This initiative had been started by members of a working group within the EUPEN network (European Physics Education Network), who presented reviews and analysis of materials on Quantum Mechanics in 2002 [1] and on Optics in 2003 [2]. Since 2004, this group collaborated on reviews of resources in Mechanics [3], on Thermodynamics and Statistical Physics [4] and on Electricity and Magnetism [5] with

the members of the MERLOT/Physics editorial board. MERLOT is based in the United States and has been performing reviews of multimedia resources in 15 different disciplines since 2000 [6].

2. Process

The process followed in these evaluations is similar to the one that has been described in previous reports and publications [1-5]. Here we briefly outline the steps in the current the review process. The steps are the discovery of materials, the initial selection of materials to be reviewed, the detailed evaluation of selected materials, and the final comparison and analysis of the results of the reviews.

a. Collection of Links

The search for resources was performed by both students and faculty at the University of Oklahoma and by researchers from the Technische Universität Kaiserslautern. The search included materials available in MERLOT, link lists, and general web searches. Efforts were made to search beyond the most well-known materials found on many link lists and course web sites. The independent searches by the two different groups were used to ensure that a larger percentage of the available resources had been discovered. More than 80% of the applets found by the Kaiserslautern search were also included in the Oklahoma search results list.

The total number of resources found for review was 66 in solid-state physics and 35 in nuclear and particle physics. Materials that were mostly text and images and did not include significant multimedia (interactive simulations, animations, video, or other interactive web sites) were not included in these lists. This is significantly less than the multimedia resources in various topics of introductory physics. Although this is probably due to the more specialized nature of the topic, a direct comparison of the number of links is not meaningful, since many small resources from a unique source were combined under a single heading, whereas they would have been listed separately in previous years.

The types of resources included for review were dependent on the topic. The Solid State teaching resources were mostly simulations illustrating the microscopic properties of materials, such as electron band structure, lattice and phonon structure, and particle transport. These simulations where mostly created by individuals or small research groups and designed for upper-undergraduate and graduate courses. The materials for particle physics, on the other hand, were often more tutorial and hands-on. The particle physics materials were often housed at the accelerator labs and were the products of large, well-funded, education and outreach collaborations. Even the particle physics resources developed and hosted by individual research groups were referenced by a large number of other groups and universities. Particle physics also had much more material aimed at a primary school, informal, and public education level than did solid state.

b. Reviews

Each item in the list given in Appendix 1 was reviewed by one member from the EPS group and one from the MERLOT group. These reviews were performed

independently and used somewhat different rubrics to provide a test of the consistency and repeatability of review results.

Since the number of items was not very large, the EPS group did not use a formal two-step review process, in contrast with the procedure used for introductory physics. Instead, all items were divided among reviewers, and each reviewer followed a review rubric that was accepted by participants at the MPTL workshops in Parma and Prague and has been published [7]. The review form (see Appendix 2) is used by reviewers to rate the best materials in the categories of **Motivation**, **Content**, and **Method**. A binary score (yes / no) is used for each question in the rubric. However, review forms were completed only for those products that the reviewers felt were of high quality with regard to these rubrics.

The MERLOT group used a two-step review process similar to that used for all MERLOT peer reviews. A preliminary triage process as completed to select items that would receive full reviews. A score from 0 to 4 was given after a quick initial review, with 4 being the highest score. Items that scored 4 received full reviews. The result of the preliminary review process was a list of 23 items, 16 in solid state and 7 in particle physics.

The full MERLOT reviews use three overall categories: **Quality of Content**, **Potential Effectiveness for Teaching and Learning**, and **Ease of Use.** These are defined by 4 or 5 questions used to rate the materials. Resources are scored on a 1 to 5 scale for each of the three categories and an overall score is given. Because these reviews are to help teachers and students discover learning resources and recognize the efforts of the authors, the completed MERLOT reviews are available online. Details of the MERLOT/Physics review process and the rubric are available [8].

Once completed, the EPS and MERLOT reviews were compared to identify high quality materials and common comments about the reviewed materials. The next section contains detailed information and recommendations for the highest quality resources. The final section gives general impressions of the reviewed Solid State, Nuclear and Particle Physics, the review process, and the future direction of this effort.

3. Recommended Resources and Websites for Solid State Physics

The following are the recommendations and comments for the Excellent and Very Good resources identified in this review

Excellent Materials:

The following resources received excellent ratings from members of both groups and are recommended for instructor and students studying these topics.

Semiconductor Applet Service: C. R. Wie, University at Buffalo,
http://jas.eng.buffalo.edu/

This site presents a large collection of simulations, animations, and tutorials on semiconductor and device physics, and semiconductor device manufacture and operation. This material includes topics ranging from crystal structure and electronic energy bands through device fabrication to circuit design and simulation. Many of the applets are interactive, allowing students to explore effects of changing parameters on the operation of devices. Many of the applets also include tutorials on the material and worksheets. Recommended mainly for university physics students but, with suitable simplifications of the supporting text, the applets can be used also at technical/vocational schools.

Solid State Electronics Applets:
http://www.benfold.com/sse/

This set of applets covers basics of quantum mechanics, electrons in crystals, junctions and lasers. Materials are presented in a simple manner both in the text and in the applets. A broad array of topics have been covered and covered well. The materials discussed are complicated. There is no clear indication about the source or authors, and more extensive documentation would help in following the materials. There are no didactic exercises or text included with the simulations.

Very Good materials:
These materials received very good ratings from reviewers, but were not rated as excellent by both groups.

Principles of Semiconductor Devices: Bart Van Zeghbroeck, University of Colorado at Boulder
http://ece-www.colorado.edu/~bart/book/title.htm

This is an advanced e-book about physics of semiconductors in general and MOSFET in particular. It provides good, in-depth coverage of the topic and is suitable for higher-level university students. This website received a good review from the EPS reviewer, but was considered average by the MERLOT reviewer. The lower MERLOT review seemed to be due to the fact that the need for multimedia was not obvious for this product.

Nanotechnology: Concord Consortium
http://mw.concord.org/modeler1.3/mirror/nanotech.html

Based on the Molecular Workbench software, this web site features a wide variety of models of crystals and nanostructures with good explanations and interpretations. This site is definitely recommended for secondary school students. Users can create their own 2-D or 3-D models using the Molecular Workbench software.

Solid State Physics: Interactive Learning: Günter Graf, Laszlo Mihaly, Carlos Rivera, Stony Brook University

http://solidstate.physics.sunysb.edu/teach/intlearn/

This is an interesting collection of simulations on lattices, phonon dispersion, band structure, and Landau levels. The materials are really presented as simulations only. This site was recommended by the EPS reviewer, but the MERLOT reviewer commented that the usage of VRML is problematic with current browsers and that the material needs more development for being effective for widespread usage by upper level students.

Spin Simulation System: Stefan Schramm, Universität Frankfurt
http://th.physik.uni-frankfurt.de/~schramm/Spinxx.html

This Java applet is a simple simulation of spin systems based on the Ising model. It includes a one-page explanation and there is only a single applet, but there are many possibilities to explore the effect of different parameters. The applet received very good reviews from both the EPS and MERLOT reviewers, although the MERLOT reviewer did not include it in the list of excellent and recommended material.

Bragg's Law and Diffraction: Konstantin Lukin, Stony Brook University
http://www.eserc.stonybrook.edu/ProjectJava/Bragg/

This web site provides and illustration and explanation of Bragg's Law using a standard model of two atomic planes. The site includes source codes, along with a good introduction to the topic. This material is easy to use, excellent and self-contained. Range of parameters is restricted. This material was recommended by the MERLOT reviewer but was considered average by the EPS reviewer who felt that the simulation did not give a good feel for the actual experiment.

4. Recommended Resources and Websites for Particle Physics

Highly rated materials for nuclear and particle physics include the following:

Excellent Material:

Fermilabyrinth
http://ed.fnal.gov/projects/labyrinth/games/index1.html
This is a collection of interactive games intended to introduce basic information on several topics: the standard model, in particular the quark model of baryons, and the fundamental forces of nature, particle accelerators, and detectors. The level is for middle and high school students and all of the games have a high motivational character (a scoring system is installed – Einstein bucks). Introductions to the topic and to the activities guarantee that even novices can have a get started successfully. Further activities go along with a learning process on the different concepts.

Hands on Particle Physics
 http://www.physicsmasterclasses.org/physics/physics.htm

This is a software package developed and assembled by EPPOG (European Particle Physics Outreach Group). The package contains information on particle physics in a number of different forms such as power point lectures, tutorials, and experiment simulations. A noteworthy part, Identifying Particles, is a huge database of original CERN data. This material is mainly intended to accompany annual master classes where high school students are invited to a nearby university. In one day, they learn basics of particle physics and detectors and analyse data from CERN detectors. The results are compared with the official CERN analysis via a videoconference. In 2008, more than 6000 high school students took part at 70 universities in 21 countries.

The Fireworks of Elementary Particle Physics: Nicholas Tracas, Elena Symeonidou
http://hands-on-cern.physto.se/ani/part_fire/fireworks.swf
This Flash tutorial covers many topics of particle physics such as structures and interactions of hadrons, quarks, fundamental forces, the Standard Model, and Feynman diagrams. The information is given in a very clear and profound manner. The user can work interactively with a particle game that is also included. The level is for high school but is also appropriate for undergraduate students.

Very good material

Microcosm - CERN
http://microcosm.web.cern.ch/microcosm/Welcome.html
Microcosm is an exhibition at the CERN campus and its web site gives an introduction and overview of the exhibits, provides teaching resources and information about educational programs, and includes web-based multimedia material in Microcosm Online. The interactive programs available in this section of the web site include the LHC Game, a very instructive guided tour to the LHC, Microboy, a game to build a carbon atom out of its constituent quarks and electrons, Powers of Ten, that allows the viewer to both zoom in to the microcosm and zoom out to the universe, and Accelerate a Particle, where the player must change electric polarities on a linear accelerator. The games are on the level of high school students and provide for some entertaining insights into specific facets of particle physics.

Lancaster Particle Physics Package
http://lppp.lancs.ac.uk/
This package is an online tutorial for high school and undergraduate students, with which basic physics and experimental techniques for the field of elementary particles are introduced. It starts with energy and momentum conservation in the interaction of particles with and without magnetic fields and ends with the search for the Higgs particle. Students can observe particle tracks and collisions and make measurements of physical properties of the particles involved.

5. General comments & Conclusions

There were several common comments made by the reviewers about the Solid State and Nuclear and Particle Physics materials reviewed. These are outlined below.

> Most of the multimedia about solid-state physics is either virtual textbooks or simulations, mostly Java applets and some VRML-based simulations. The applets generally work well.

> The translation of a traditional textbook to an e-version with multimedia applications provided through links to other authors' materials worldwide is too heterogeneous, does not fulfilling our criteria of quality, and is of little use for colleagues or students.

> A good simulation program for a single isolated problem must fulfill minimum quality demands such as text explaining the application and usage, self-evident operation and interactivity, excellent programming, and convincing visualization.

> The most highly rated resources are simulations or tutorial web pages that are part of a larger collection. These collections provide a broad, consistent, and refined set of learning materials that can be used throughout or in combination with a standard class. They have more text and learning content, whereas the single purpose items tend to have less explicit documentation. It is difficult to review these smaller resources without the context of how the item will be used. These items may be very useful for the person who developed them with a specific didactic goal in mind, but appear less convincing to others.

> Compared to introductory physics, the ratio of the number of good resources to the total number of items reviewed is larger. There also seems to be less duplication of resources covering standard topics, although crystal structures and reciprocal lattices are popular themes.

In the first two years when joint EPS and MERLOT reviews were performed, covering Mechanics and Statistical and Thermal Physics, there had been good agreement between the reviewers of the two groups. Last year, however, there was more divergence in recommendations between EPS and MERLOT reviewers for the Electricity and Magnetism materials. In several cases, one reviewer gave a relatively high score while the other reviewer considered the material average. This year there is again much better agreement. The differences are mainly between one group ranking an item as "excellent" and the other group ranking it as "very good".

The review group has decided that quantum mechanics will be the next topic reviewed. This will be a revisit of the first topic considered by the EPS group in 2002. It has been suggested that continuing a cycle of review topics is appropriate because of new materials being developed and some resource no longer being available.

References

[1] M. Benedict, E. Debowska, H. J. Jodl, L. Mathelitsch, R. Sporken, "Recommendations (for material on quantum mechanics and for evaluation criteria)", 7th Workshop on Multimedia in Physics Teaching and Learning of the European Physical Society – Proceedings, (Parma, Italy 2002), available online http://www.mptl.eu/reports_files/Rep_QM_2002.pdf (Accessed 5/14/2008)

[2] M. Benedict, E. Debowska, H. J. Jodl, L. Mathelitsch, R. Sporken, "Report and Recommendations on Available Multimedia Material for Teaching Optics at School and at University Level", 8th Workshop on Multimedia in Physics Teaching and Learning of the European Physical Society – Proceedings, (Prague, Czech Republic 2003) http://www.mptl.eu/reports_files/Rep_Recom_Optics_2003.pdf (Accessed 5/14/2008)

[3] M. Benedict, E. Debowska, H. J. Jodl, L. Mathelitsch, R. Sporken, T. Bradfield, T. Colbert, L. Keiner, B. Mason, T. Meldor, S. Sen, J. Rauber, "Report and Recommendations on Available Multimedia Material for Teaching Mechanics at School and at University Level", 9th Workshop on Multimedia in Physics Teaching and Learning of the European Physical Society – Proceedings, (Graz, Austria 2004) http://www.mptl.eu/reports_files/Rep_Recom_Mechanics_2004.pdf (Accessed 5/14/2008)

[4] L. Mathelitsch, B. Mason, H.J. Jodl, et. al, "Report and Recommendations on Available Multimedia Material for Statistical and Thermal Physics", 10th Workshop on Multimedia in Physics Teaching and Learning of the European Physical Society – Proceedings, (Berlin, Germany 2005) http://www.mptl.eu/reports_files/Rep_Recom_Thermodyn_2005.pdf

[5] M. Benedict, E. Debowska, B. Eckert, S. Feiner-Valkier, H. J. Jodl, L. Mathelitsch, I. Ruddock, E. Sassi, R. Sporken, T. Bradfield, T. Colbert, B. Mason, T. Melder, J. Rauber, S. Sen, "Report and Recommendations on Available Multimedia Material for Electricity and Magnetism", 11th Workshop on Multimedia in Physics Teaching and Learning of the European Physical Society – Proceedings, (Szeged, Hungary 2006) http://www.mptl.eu/reports_files/Rep_Recom_ElectMag_2006.pdf (Accessed 5/14/2008)

[6] MERLOT is available online at http://www.merlot.org. More information about the MERLOT Project is available online at http://taste.merlot.org, and the portal page for MERLOT/Physics is http://portals.merlot.org/physics/.

[7] S. Altherr, A. Wagner, B. Eckert, H. J. Jodl, „Multimedia material for teaching physics (search, evaluation and examples)", European Journal of Physics 25 (2004)

[8] Available online at http://portals.merlot.org/physics/PeerReviewOverview.html

Appendix 1:

List of items reviewed

Site	URL	Author
Crystal Lattice-Structures	http://cst-www.nrl.navy.mil/lattice/	Naval Research Lab?
Transverse and Optical Phonon Dispersion	http://fermi.la.asu.edu/ccli/applets/phonon/index.html	Michael Lee, Kevin Schmidt
Principles of Semiconductor Devices	http://ece-www.colorado.edu/~bart/book/title.htm	Bart Van Zeghbroeck
Kronig-Penney Applet	http://fermi.la.asu.edu/schmidt/applets/kp/plugkp.html	Michael Lee, Kevin Schmidt
Hyperphysics Solid State	http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html	Rod Nave
Fermi Distribution with Temperature	http://ist-socrates.berkeley.edu/~cywon/Distribution.html	Changyeon Won
2D Phonon Modes	http://ist-socrates.berkeley.edu/~cywon/NewPhonon.html	Changyeon Won
Semiconductor Applet Service	http://jas.eng.buffalo.edu/	C. R. Wie
Steffen Weber Home page	http://jcrystal.com/steffenweber/	Steffen Weber
Resistivity Parameters	http://materials.npl.co.uk/NewIOP/Resistivity.html	NPL
Symmetry and crystals	http://mineral.galleries.com/minerals/symmetry/symmetry.htm	Amethyst Galleries
Nanotechnology	http://mw.concord.org/modeler1.3/mirror/nanotech.html	Concord Consortium
Nano Atlas	http://nanoatlas.ifs.hr/index_1.html	Antonio Šiber
Solid State Simulation Project	http://pages.physics.cornell.edu/sss/	Robert H. Silsbee and Joerg Draeger
X-ray View	http://phillips-lab.biochem.wisc.edu/software.html	George N. Phillips,
RFIM and Push-Relabel	http://physics.syr.edu/research/condensedmatter/RFIM/	
Solid State physics: Interactive Learning	http://solidstate.physics.sunysb.edu/teach/intlearn/	Laszlo Mihaly
Electrons in a 2D lattice	http://solidstate.physics.sunysb.edu/teach/intlearn/electrons/electrons.html	Laszlo Mihaly
Landau Levels	http://solidstate.physics.sunysb.edu/teach/intlearn/landau/landau.html	
Reciprocal Lattice	http://solidstate.physics.sunysb.edu/teach/intlearn/lattice/lattice.html	
Phonon Dispersion	http://solidstate.physics.sunysb.edu/teach/intlearn/phonon/phonon_dispersion.html	
Spin System Simulation	http://th.physik.uni-frankfurt.de/~schramm/Spinxx.html	Stefan Schramm
Ising Model	http://webphysics.davidson.edu/Applets/ising/default.html	Wolfgang Christian
X-Ray Diffraction from Atomic Planes	http://www.abdn.ac.uk/physics/vpl/bragg/index.html	Gary Skinner
Haynes-Shockley Esperiment	http://www.acsu.buffalo.edu/~wie/applet/diffusion/diffusion.html	C R Wie
IBM STM images	http://www.almaden.ibm.com/vis/stm/stm.html	IBM
Magnetic Excitations in Ferromagnets	http://www.angelfire.com/wa/hurben/mag.html	Michael J. Hurben
Solid State Electronics Applets	http://www.benfold.com/sse/	
Structures of Simple Inorganic Solids	http://www.chem.ox.ac.uk/icl/heyes/structure_of_solids/Strucsol.html	S. J. Heyes
Reciprocal Lattice	http://www.chembio.uoguelph.ca/educmat/chm729/recip/vlad.htm	Vlad Zamlynny
Sandpile Applet	http://www.cmth.bnl.gov/~maslov/Sandpile.htm	Sergei Maslov
Electron Transport Simuations	http://www.collage.soe.ucsc.edu/available_applets.htm	Ali Shakouri
Microelectronics Courses	http://www.elec.gla.ac.uk/groups/sim_centre/courses_nf.html	University of Glasgow
Structure Factor	http://www.embl-hamburg.de/%7Etilo/sfapplet/sfintro.html	Kevin Cowtan

Bragg Reflection	http://www.eserc.stonybrook.edu/ProjectJava/Bragg/	Konstantin Lukin
Crystal Growth Applet	http://www.eserc.stonybrook.edu/ProjectJava/CrystalGrowth/Spiral/	Glenn Richard
Crystal Growth Applet	http://www.eserc.stonybrook.edu/ProjectJava/CrystalGrowth/Flat/index.html	Glenn Richard
Open Phonon	http://www.esrf.eu/computing/scientific/OpenPhonon/manual/index.html	
Kronig-Penney	http://www.falstad.com/qm1dcrystal/	Paul Falstad
3D Solid State Crystal models	http://www.ibiblio.org/e-notes/Cryst/Cryst.htm	Evgeny Demidov, Yury Drozdov
Crystal Structures	http://www.ill.fr/dif/3D-crystals/index.html	Hewat
Ineractive Tutorial about Diffraction	http://www.mineralogie.uni-wuerzburg.de/crystal/teaching/teaching.html	Th. Proffen, R. B. Neder
Functional combinations in solid states	http://www.mtmi.vu.lt/pfk/funkc_dariniai/program.htm	Vladimir Gavryushin
The Ising Model	http://www.phy.syr.edu/courses/ijmp_c/Ising.html	Simon Catterall, Syracuse University
Fermi Surface Database	http://www.phys.ufl.edu/fermisurface/	Chris Stanton
Kronig-Penney	http://www.sc.ehu.es/sbweb/fisica/cuantica/lineal/lineal.htm	Angel Franco Garcia
Kronig-Penney Applet	http://www.technion.ac.il/~emanuele/kp/	
Semiconductor Physics Hypertextbook	http://www.tf.uni-kiel.de/matwis/amat/semi_en/	Helmut Foll
Tight Binding Program for Computing Band Structure of Semiconductors	http://www.wag.caltech.edu/home/rpm/projects/wurtzite/	
2D Ising Model	http://www2.truman.edu/~velasco/ising.html	
NanoHub	https://www.nanohub.org/	NanoHub
Fermi Surface Images	http://www.phy.tu-dresden.de/%7Efermisur/	Peter Zahn, Ingred Mertig
Nanotubes made simple	https://www.ccs.uky.edu/~ernst/carbontubes/structure.html	Ernst Richter
Diffraction Tutorials	http://www.matter.org.uk/diffraction/introduction/default.htm	
Diffusion Limited Aggregation	http://www.shodor.org/refdesk/Resources/Models/DLA/#	CSERD
Condensed Matter Pictures	http://www.seas.harvard.edu/weitzlab/pics.html	David Weitz
Transistorized: The history of the transistor	http://www.pbs.org/transistor/	AIP History Center and PBS
Music of the Quantum	http://musicofthequantum.rutgers.edu/	
The Neutrino Mass Toy	http://cupp.oulu.fi/neutrino/tt-mass.html	Juha Peltoniemi
Searching for the Building Blocks of Nature	http://ed.fnal.gov/projects/exhibits/searching/	FermiLab
Fermilabyrinth	http://ed.fnal.gov/projects/labyrinth/games/index1.html	FermiLab
The Fireworks of Elementary Particle Physics	http://hands-on-cern.physto.se/ani/part_fire/intro_eng.swf, http://pdg.lbl.gov/fireworks/intro_eng.swf	Elena Symeonidou
Hands on CERN	http://hands-on-cern.physto.se/hoc_v21en/index.html	CERN
An Introduction to Particle Physics	http://hepwww.rl.ac.uk/Pub/Phil/ppintro/ppintro.html	RAL
Interactive Plasma Physics Experience	http://ippex.pppl.gov/	IPPEX
The Rutherford Experiment	http://micro.magnet.fsu.edu/electromag/java/rutherford/	Michael Davidson
Microcosm online	http://microcosm.web.cern.ch/microcosm/Content/Online/Online-en.html	CERN
Nuclear Structure and Decay Data	http://nucleardata.nuclear.lu.se/database/masses/	Peter Ekström

The OPAL Experiment at LEP	http://opal.web.cern.ch/Opal/	OPAL
The Particle Adventure	http://particleadventure.org/index.html	Particle Adventure
Anatomy of a Detctor	http://quarknet.fnal.gov/run2/boudreau.shtml	Thomas Jordan, FermiLab
The Official String Theory Web Site	http://superstringtheory.com/index.html	Patricia Schwarz
Light Isotope Nuclear Decay	http://www.colorado.edu/physics/2000/applets/iso.html	Martin Goldman
Physics 2000: Isotopes and Radiation	http://www.colorado.edu/physics/2000/isotopes/index.html	Martin Goldman
Bubble Chamber	http://www.ep.ph.bham.ac.uk/user/watkins/seeweb/BubbleChamber.htm	Peter Watkins, Tom Adams
Natural Radioactive Series	http://www.eserc.stonybrook.edu/ProjectJava/Radiation/index.html	Yevgeniy Miretskiy
The Quantum Universe	http://www.interactions.org/quantumuniverse/	High Energy Physics Advisory Panel (DOE/NSF)
A Science Odyssey: Atom Builder	http://www.pbs.org/wgbh/aso/tryit/atom/#	WGBH
Cyclotron	http://www.phy.ntnu.edu.tw/ntnujava/index.php?topic=33.msg199#msg199	Fu-Kwan Hwang
Radioactive Decay	http://www.phy.ntnu.edu.tw/oldjava/decay/decay.html	Fu-Kwan Hwang
EPPOG: Hands on Particle Physics	http://www.physicsmasterclasses.org/physics/physics.htm	EPPOG
La desintegración radioactiva	http://www.sc.ehu.es/sbweb/fisica/cuantica/desintegracion/radio.htm	Angel Franco-Garcia
Dispersión de partículas alfa por un núcleo	http://www.sc.ehu.es/sbweb/fisica/cuantica/dispersion/dispersion.html	Angel Franco-Garcia
The Law of Radioactive Decay	http://www.walter-fendt.de/ph11e/lawdecay.htm	Walter Fendt
The History of Neutrinos	http://wwwlapp.in2p3.fr/neutrinos/aneut.html	Didier Verkindt
A Keyhole to the Birth of Time	http://www.physicsmasterclasses.org/exercises/keyhole/en/Welcome.html	CERN
Identifying Interesting Particle Physics Events and LEP	http://www.physicsmasterclasses.org/exercises/manchester/en/home.html	LEP
Lancaster Particle Physics Package	http://www.physicsmasterclasses.org/exercises/lancaster/en/index.html	Lancaster University
Universal Nuclei Chart and Decay Applet	http://www.nuclides.net/applets/radioactive_decay.htm	Yvonne Galla

Appendix 2: EPS Review Sheet

URL Comment: Recommendation:		
User-friendliness:	**Rating**	**Comments**
Is it easy to start using the MM?		
Are the design comprehensible and the image quality satisfactory?		
Is the function of control elements evident?		
Are the software requirements clear and of adequate proportion?		
Attractiveness:		
Is the layout appealing?		
Is there a motivating introduction?		
Are there interactive components?		
Is the topic interesting (reference to everyday life, applications, explaining a phenomenon)?		
Is the MM up-to-date / innovative?		
Clear description of purpose and work assignment:		
Is the intention of the MM evident?		
Does the user know what is expected from him?		
Is there a problem to solve or a context to understand?		
Relevance:		
Is the topic important?		
Does it make sense to use the MM (e.g. problems in understanding, dynamic process)?		
Scope:		
Is there a profoundness of content?		
Is there a broadness of content (special case, general overview)?		
Correctness:		
Is the content of the MM correct?		
Are simplifications indicated?		
Flexibility:		
Is the MM appropriate for a broad target group (incl. self-learning)?		
Is it possible to use the MM in different teaching and learning situations?		
Does the MM allow for the same topic to be approached in different ways?		

Matching to target group:		
Is a reasonable didactical reduction implemented?		
Are technical terms explained?		
Are the objectives appropriate?		
Realization:		
Is the general approach suitable to present the subject and realize aims of the given MM?		
Is the type of MM chosen reasonable (video, simulation, animation)?		
Documentation:		
Is the operation obvious or explained?		
Is the material self-evident or explained by additional text?		
Is there a reference to material for further studies?		
Are there any suggestions for implementation into the teaching process?		