NATIONAL COLLEGE (AUTONOMOUS), TIRUCHIRAPPALLI-620 001
M.Phil. PHYSICS (CBCS)
(For the candidates admitted from the year 2016-2017 onwards)

CORE COURSE –I
RESEARCH METHODOLOGY AND EDUCATIONAL TECHNOLOGY

UNIT I: BASICS OF RESEARCH

Meaning, purpose and characteristics of research – Characteristics of a researcher-Classification of research- Research process- Scientific research – Aim and motivation- Principles and ethics - Identification of research problem-Formulation of objectives execution plan – Current status – Literature survey – Abstraction of a research paper – Access using internet web tools – Email – Impact and usefulness of the research problem – Role of research guide – Guidance and rapport - Preparation and presentation of scientific reports- Need and methods (Oral and poster) –Writing of synopsis and dissertation and thesis.

UNIT II: METHODS OF DATA ANALYSIS

Data-data collection – Statistical description of data (mean, variance, skewness, median, and mode) – Distributions (Student's t-test, F-test, Chi-square test), Correlation (linear and nonparametric/rank); Modeling data: Least squares, Fitting data – linear and non-linear models. Pictorial representation of data – Use of open source statistical software packages for computational needs (Basic ideas).

UNIT 3: MODERN RESEARCH PRACTICES IN SCIENTIFIC RESEARCH

Usage of open source software and freely licensed software for research work and data analysis – Effective use of internet for research needs-Collaborative work-Interdisciplinary research-scholarly research articles –National, International and Electronic Journals- Online submission of research articles -Open access articles-benefits- Impact factor, h-index- Citations- Seminars, workshops, conferences and symposia- Respecting copy rights- Avoiding plagiarism- Intellectual property rights and patents.

UNITIV:EDUCATIONALTECHNOLOGY

Origin-History-Meaning and definitions of educational technology-Objectives, forms and approaches-scope, significance and uses of educational technology-System concept-Types-parameters-steps involved in system approach-Educational system-Instructional system.

UNITV: INFORMATION AND COMMUNICATIONALTECHNOLOGY

Meaning of information and communicational technology (ICT)-Definition- Features-Trends- Uses and limitations- Characterizes of e-learning- Advantages and limitations- Integration of ICT in teaching and learning- ICT applications: using word processors, spreadsheets-power point slides in the classroom-ICT for research: on-line journals- e-books, technical reports, thesis and dissertations- Computer medicated teaching: multimedia, e-content.

Books for study and references:
For Units I to III.

1.G.Vijayalakshmi and C.Sivapragasam, Research Methods (Tips and techniques) MJP publishers, Chennai2008.

2. Gupta.S.C & Kapoor,V.K, Fundamentals of Mathematical Statistics, Sultan Chand & sons, New Delhi -1994.

3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Private Limited, 1999.

4. Internet : An Introduction, CI Systems School of Computing, Jaipur, Tata Mc Graw Hill, New Delhi (1999)

5.Lecture notes and course material: Modern Research Practices in Scientific Research by Dr.T.V.Sundar, Department of Physics, National College (Autonomous), Tiruchirappalli, 2015.

For Unit IV and V.

6. S.K.Mangal and Uma Mangal, Essentials of Educational technology prentice Hall of India Pvt Ltd, New Delhi,2009.

7.R.A.Sharma,Fundamentals of Educational technology, Surya publications, Meerut, 2006

8. Michael D and William, Integrating technology into teaching and Learning: concepts and applications, prentice Hall New York, 2004.

9. Kumar K.L Educational technology, New Age International publishers, 2008.

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CORE COURSE II: ADVANCED PHYSICS

Unit I: CRYSTAL GROWTH TECHNIQUES

Nucleation-Spherical and cylindrical nucleation-Solution growth methods: Slow cooling, slow evaporation and temperature gradient methods-Melt growth: Bridgeman method-Czochralski method.

Unit II: THIN FILM PHYSICS

Thin film physics: Physical methods-Thermal evaporation-Electron beam evaporation-Sputtering method-Chemical methods: Chemical bath deposition-Spray pyrolysis-Chemical Vapour Deposition (CVD).

Unit III: NON-LINEAR OPTICS

Double refraction: Optical indicatrix-Effect of crystal symmetry on Optical indicatrix-Wave surface: Uniaxial and Biaxial crystals-Non-Linear Optics: Harmonic generation-Second Harmonic generation-Kurtz and Perry powder technique-Phase matching-Third harmonic generation-Optical mixing: Sum and difference frequencies-Parametric generation of light-Self-focusing of intense light beams.

Unit IV: NANOTECHNOLOGY

Introduction to Nanotechnology- Importance of Nano materials- Types of Nano structures (1D, 2D, 0D)- Self Assembled Monolayers (SAM)-Vapour Liquid Solid (VLS)- Carbon Nano Tubes(CNT)-Metals (Ag,Au)- Metal oxides (Tio_2,ZnO)-Semiconductors (CdS, ZnSe).

UNIT V: ADVANCED MATHEMATICAL METHODS FOR RESEARCH PHYSICS

Mathematics: Hypergeometric Function – Confluent Hypergeometric function. Dominant Eigen value of a matrix and vectors -Power method - Numerical solution of ODE: Runge - Kutta 2^{nd} order and 4^{th} order method- Linear second order differential equations with variable coefficients – Frobenius method – Series solution - Binomial, poisson and Gaussian distributions – General properties – Numerical problems.

Books for Study and Reference:

Unit I

1. J.C.Price, Crystal Growth Processes, John Wiley and sons, New York(1986).
2. P.Santhana Raghavan and P.Ramasamy, Crystal Growth Processes and Methods, KRU Publications, Kumbakonam(2000).

Unit II

3 A.Goswami, Thin Film Fundamental, New Age International (P)Ltd. New Delhi(2006)

4 Leonard C.Feldmann and James W.Mayer, Fundamentals of Surface and Thin Film Analysis.

Unit III

5 B.B.Laud, Lasers and Non –Linear Optics, Wiley Eastern Ltd., 1985.

Unit IV

6.G.Cao,Nano Structures and Nano materials: Synthesis properties and applications, Imperical College press,(2004).

Unit V

7.Mathews and R..L. Walker, Mathematical Methods of Physics (Pearson Education, New Delhi, (2004).

8.P.K.Chattopadhyay, Mathematical Physics, Wiley Eastern Ltd., New Delhi (1990)

9.M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Private Limited, 1999.

CORE COURSE III : MATERIALS CHARACTERIZATON

OBJECTIVE: *To expose the student with thermal, microscopic, electrical and spectroscopic methods of characterization.*

UNIT I THERMAL ANALYSIS

Introduction – Thermo gravimetric analysis (TGA) – Instrumentation – Determination of weight loss and decomposition products – Differential thermal analysis (DTA)- cooling curves - Differential scanning calorimetry (DSC) – Instrumentation – Specific heat capacity measurements – Determination of thermo mechanical parameters .

UNIT II MICROSCOPIC METHODS

Optical Microscopy: Optical microscopy techniques – Bright field optical microscopy – Dark field optical microscopy – Dispersion staining microscopy - Phase contrast microscopy - Differential interference contrast microscopy - Fluorescence microscopy - Confocal microscopy - Digital holographic microscopy - Oil immersion objectives - Quantitative metallography - Image analyzer.

UNIT III ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY

SEM, EDAX, EPMA, TEM: Working principle and Instrumentation – Sample preparation – Data collection, processing and analysis- Scanning Tunneling Microscopy(STEM)- Atomic Force Microscopy(AFM) - Scanning new field optical microscopy

UNIT IV ELECTRICAL METHODS AND OPTICAL CHARACTERISATION

Two probe and four probe methods- Van der Pauw method – Hall probe and measurement – Scattering mechanism – C-V characteristics – Schottky barrier capacitance – Impurity concentration – Electrochemical C-V profiling – Limitations. Photo luminescence – Light – Matter interaction – Instrumentation – Electro luminescence – Instrumentation – Applications.

UNIT V X-RAY AND SPECTROSCOPIC METHODS

Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, ESR, NMR,NQR, XPS, AES and SIMS-Proton induced X-ray Emission spectroscopy (PIXE) –Rutherford Back Scattering (RBS) analysis-Application - Powder diffraction - Powder diffractormeter - Interpretation of diffraction patterns - Indexing - Phase identification - Residual stress analysis - Particle size, texture studies - X-ray fluorescence spectroscopy - Uses.

REFERENCES

1. Stradling, R.A; Klipstain, P.C; Growth and Characterization of semiconductors, Adam Hilger, Bristol, 1990.
2. Belk, J.A; Electron microscopy and microanalysis of crystalline materials, Applied Science Publishers, London, 1979.
3. Lawrence E.Murr, Electron and Ion microscopy and Microanalysis principles and Applications, Marcel Dekker Inc., New York, 1991
4. D.Kealey and P.J.Haines, Analytical Chemistry, Viva Books Private Limited, New Delhi, 2002.

ELECTIVE COURSE– IV: MATERIALS SCIENCE

Objectives:

- *To study the crystal structure*
- *To study Nucleation and Kinetics of Crystal Growth*
- *To learn* solution growth techniques
- *To learn* melt and vapour growth techniques
- *To study analytical techniques*

Unit: I CRYSTAL STRUCTURE

Periodic array of atoms-Symmetry operations- the basis and crystal structure-Primitive cell-Fundamental types of lattices-Simple crystal structures-Crystal diffraction and reciprocal lattices-Experimental diffraction methods-Diffraction types-Bonding in solids and their characteristics.

Unit: II NUCLEATION

Nucleation – Theories of nucleation – Classical theory of nucleation – Gibbs Thomson equation for vapour – Modified Thomson's equation for melt –Gibbs – Thomson equation for solution-Energy of formation of a nucleus-Spherical nucleus – Cylindrical nucleus – Homogeneous and Hetergeneous nucleation- Kinetics of crystal growth (Basis only).

Unit: III SOLUTION GROWTH TECHNIQUES

Low temperature solution growth: Solution – Solubility and supersolubility – Expression of supersaturation – Mier's T- C diagram – Constant temperature bath and crystallizer – Seed preparation and mounting – Slow cooling and solvent evaporation methods – Gel growth – various types – Structure of gel – Importance of gel technique- Chemical reaction method – Single and double diffusion method – Chemical reduction method – Complex and decomplexion method – Solubility reduction method – Advantages of gel method – High temperature solution growth – Hydrothermal growth – Flux growth.

Unit: IV MELT AND VAPOUR GROWTH TECHNIQUES

Phase diagram and phase rules (basic concept) – Melt techniques – Bridgman technique-Basis process – Various crucible design – Thermal consideration – Vertical Bridgman technique – Experimental arrangement – Czochralski technique – Experimental arrangement –Verneuil method – Vapour growth – Basics of vapour growth – Chemical vapour transport (CVT) - Experimental arrangement.

Unit V: ANLYTICAL TECHNIQUES

Characteristics-Physical parameters-Basic principles and description of techniques-X-rays- UV- IR- Visible- Raman and FTIR spectroscopy, DTA-TGA-DSC thermal studies- NMR Techniques- Dielectric Studies- Photoconductivity studies-Microhardness studies-SEM and TEM techniques-NLO studies-Kurtz –Perry powder technique.

Books for Study and References:

1. C. Kittel, Introduction to Solid State Physics Wiley Eastern, New Delhi (1977).
2. M. M. Woolfson, An Introduction to X-ray Crystallography (Cambridge University Press, Cambridge, 1991).
3. S. O. Pillai, Solid State Physics (New Age International, New Delhi, 1995).
4. N. W. Ashcrof and N. D. Mermin, Solid State Physics (Holt, Rinehart and Winston, Philadelphia).
5. J. S. Blakemore, Solid State Physics (Cambridge University Press, Cambridge, 1974).
6. A. J. Dekker, Solid State Physics (McMillan, Madras, 1971).
7. J.C. Brice, Crystal Growth Processes, John Wiley and Sons, New York 1986.
8. P.Santhana Raghagavan and P.Ramasamy, Crystal Growth Process and methods, KRU Publications, Chennai, 2004.
9. Buckley H.E. (1951), 'Crystal Growth', John Wiley and Sons, New York.
10. Elwell D. and Scheel H.J. (1975), 'Crystal Growth for High Temperature Solutions', Academic Press Inc., London.
11. Silverstein, R.M., Glayton Bassiler, G. and Mozill, T.C., Spectroscopic Identification of Organic compounds, Fourth edition, John Wiley and sons, New York (1981).
12. Kurtz S.K. and Perry T.T. (1968), 'A Powder technique for the evaluation of nonlinear optical materials', J. Appl. Phys., Vol. 39,pp. 3798–38l3.
13. Anderson J.C. (1964), Dielectrics, Chapman and Hall, London.
14. Joshi V.N. (1990), 'Photoconductivity', Marcel Dekker, New York.
15. Onitsch E.M. (1956), 'The present status of testing the hardness of materials', Mikroskopie, Vol. 95, pp. 12-14.

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ELECTIVE COURSE– IV:VIBRATIONAL SPECTROSCOPY

Semester -I **Course Code :**
Instruction hrs /week: 6 hrs. **Credit :**

Objectives:

- *To understand the basic concept to atomic spectra*
- *To learn atoms in external fields and quantum chemistry*
- *To study microwave and ir spectroscopy, raman spectroscopy and electronic spectroscopy and resonance spectroscopy of molecules.*

UNIT- I: CONCEPTS OF SPECTROSCOPY

Introduction to spectroscopy – properties of electromagnetic radiation - spectrum-different types of molecular energies- electronic spectra of diatomic and poly atomic molecules – importance of vibrational spectroscopy-Descriptions of vibrations-Fermi Resonance- Group frequencies- Coupled vibrations.

UNIT-II : MOLECULAR VIBRATIONS:

Classification of the normal vibrations – determining the symmetry types of the normal modes-selection rules for vibrational transitions force constants –F and G matrix method-over toners and combination bands-Internal and symmetry coordinates-band assignments-refinement of force constants.

UNIT -III: INFRARED SPECTROSCOPY:

Introduction – Principle of infrared spectroscopy – molecular vibrations-vibrational frequency-number of fundamental vibrations-selection rules-factors influencing vibrational frequencies-infrared instrumentation-sampling techniques-finger print region-important features of infrared spectroscopy-applications of infrared spectroscopy-interpreting an infrared spectrum

UNIT-IV: RAMAN SPECTROSCOPY:

Introduction – classical theory of Raman scattering-quantum theory of Raman effect – Theory of Raman spectra-General selection rule for Raman scattering – Raman spectra of diatomic molecules-vibrational Raman spectra of polyatomic molecules – Rule of mutual exclusion principle-infrared and Raman spectra are complimentary-structure elucidation by Raman spectroscopy-Instrumentation and sampling techniques-importance of Raman spectra-application of Raman Spectroscopy.

UNIT- V : NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY:

Principles – origin of NMR- Modes of nuclear pin – Instrumentation – Measurements of NMR spectra – Relaxation process- Chemical shift – Shielding and deshielding effects – Factors affecting chemical shift – Anisotropic effects – Peak area and proton counting – splitting of the signals – Spin-spin coupling – Proton exchange reactions – Coupling constants – Other couplings.

BOOKS FOR REFERENCES:

1. Vibrational Spectroscopy – Theory and Applications, D.N.Sathyanaraya, New age International Publishers, New Delhi 2004.
2. Spectroscopy – Atomic and molecular, Gurdeep R.Chatwal, Sham K. Anand, Himalaya Publishing House, Delhi, 2004.
3. Modern Molecular Spectroscopy – H.S.Randhawa, MacMillan India Ltd.2003.
4. Chmical Applications of Group Theory, F Albert Cotton, Wiley Eastern Ltd., New Delhi, 1988.
5. Molecular Structure and Spectroscopy, G. Aruldhas, PHI Learning Private Limited, New Delhi (2009).
6. Gupta, S.L.Kumar, Sharma, Elements of Spectroscopy, Pragati Prakasham Publication, Meerut(2009).
7. P.S.Sindhu, Elements of Molecular Spectroscopy, New Age International 2007.
8. A.K.Chandra, Introductory Quantum Chemistry, Mc Graw Hill, New Delhi 2003
9. C.N.Banwell, Elaine M.Mc Cash, Fundamental of Molecular Spectroscopy (Mc Graw Hill, New Delhi 2010).

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ELECTIVE COURSE– IV: THEORETICAL CHARACTERISATION OF AMINO ACIDS

Objectives:

- *The syllabus is framed such that the candidate could well understand the fundamentals about the amino acids, their properties, synthesis and some of the measurement techniques. This fundamental are applied to characterize amino acids using certain classical models.*

Unit – 1 INTRODUCTION

Laws of thermodynamics – first, second, third and zeroth laws. – Laws of mass action – Measurements of pH – Identification of functional groups – Amines – Types of bio molecules – importance of biomolecules.

Unit – 2 AMINO ACIDS AND PEPTIES

Amino acids : Structures, classification, physical and chemical properties. Titration curves of amino acids. Peptides : amides, peptide bonds, biological importance of peptides.

Unit – 3 EQUATION OF STATE

Introduction to L-J potential parameters – Chemical potential – Types of equations of state – Percus- Yevick , MCSL , MC- analysis of equation of state - applied to liquids

Unit – 4 MEASUREMENT BASICS

Sound velocity measurement using Ultrasonic interferometer – Basic principles of Scanning Electron Microscope, Tunneling Electron Microscope, Scanning Transmission Microscope – particle size determination methods.

Unit – 5 ANALYTICAL INSTRUMENTS

Basic principles and applications of Nuclear Magnetic Resonance – Circular Dicroism – Electron Spin Resonance - Basic ideas about COSPY and NOSOY peak formations in NMR.

Books for study:

1.Fundamentals of Biochemistry – O.P Agrawal, S Chand publ.
2.Essential of Biochemistry – M.C Pant, Tata Mc Graw Hill publi
3.Biophysical chemistry – Principles and techniques – Upadyay and Nath, Prantice Hall publ.

Books for Reference:

1. Basic one and two dimensional spectroscopy – Horst Friebolin – VCH pub:1991.
2. Principles and techniques of practical biochemistry – Wilson and Walker.

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ELECTIVE COURSE– IV: ULTRASONICS AND INSTRUMENTATION

Unit I: Introduction to Ultrasonics and study of Liquid Mixtures

Equation of a Progressive wave-Wave parameters-wavelength-amplitude-frequency-time period-phase- Velocity-Modes of Ultrasonic waves -longitudinal-transverse-surface-plate waves.

Types of Molecular interactions-Ultrasonic study of molecular interactions-preparation of liquid mixtures-mole fraction-weight& volume fraction

Unit II: Experimental techniques and Acoustical parameters

Experiment to determine velocity-Interferometer-continuous method- experiment to determine density- specific gravity bottle- experiment to determine viscosity- Oswald viscometer method.

Acoustical parameters from velocity and other data: Adiabatic compressibility-acoustic impedance-intermolecular free length-molar volume-free volume-internal pressure-classical absorption- Gibb's energy-Apparent molar compressibility.

Unit III: Infra Red Spectroscopy

Introduction-requirements for IR radiation absorption-origin of IR spectra-selection rules- vibrational modes of atoms-Stretching and bending vibrations-Infrared spectrometer- source- monochromator- sample-detector- amplifier- double beam spectrophotometer- advance spectrophotometers- interpretation of spectra-examination of an IR spectrum-finger print region.

Unit IV: Nuclear Magnetic Resonance Spectroscopy

Introduction-principle of NMR spectroscopy-origin of NMR-modes of nuclear spin-NMR instrumentation-measurement of NMR spectra-relaxation process-spin-spin relaxation-spin-lattice relaxation-chemical shift-factors affecting chemical shift-intermolecular factors affecting chemical shift-spin-spin coupling-tips for interpreting an NMR spectrum-limitations of NMR studies-Applications of NMR spectroscopy.

Unit V Raman Spectroscopy

Introduction-differences of Raman and IR spectra-theory of Raman spectroscopy-mathematical explanation of Stokes and Antistoke's lines-polarizability-raman instrumentation-source-sample holder-monochromator-detector-Perkin-Elmer Raman spectrometer-interpretation of Raman lines-intensity of raman spectrum-applications of Raman spectroscopy in inorganic-organic and physical chemistry.

Books for Study:

1. Baldevraj, V.Rajendran and P.Palanichamy, Science and technology of Ultrasonics , Narosa publications (2007) (Unit I, II only).
2. H.Kaur ,Spectroscopy ,Pragati Prakashan Publications (2004) (Unit III, IV, V)

Books for Reference:

1. Fundamentals of Ultrasonics –Blitz.J, 2nd edition Butterworth London (1967).
2. Molecular theory of Solutions, Prigogine I, North-Holland pub co, Amsterdam (1959).
3. Atomic and Molecular spectroscopy-Gurdeep R.Chatwal, Sham K.Chand, Himalaya publishing house.

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ELECTIVE COURSE– IV: PARTICLE AND MATERIAL SCIENCE

Objectives:

- To acquire the knowledge about the nuclear and particle physics.
- To learn crystal growth and thin films techniques.
- To highlight the importance of nanotechnology

UNIT I: NUCLEON STRUCTURE FUNCTION

Quarks as the Building Blocks of Hadrons - Baryon Magnetic Moments -Discovery of Heavier Quarks - Colour Degree of Freedom - Nucleon Structure Function - The Bjorken Scaling - The Quark Parton Model. DIS Experiments of Polarized Leptons on Polarized Nucleons - The Statistical Model of the Nucleon.

UNIT II: GROWTH TECHNIQUES

Low temperature solution growth: Solution - Solubility and super solubility – Expression of super saturation – Mier's T-C diagram - Seed preparation and mounting - Slow cooling and solvent evaporation methods - Principle – Various types – Structure of gel – Importance of gel – Experimental-procedure - Bridgman technique - Czochralski technique – Experimental arrangement – Growth process - Physical vapour deposition – Chemical vapour deposition (CVD) .

UNIT III : THIN FILM DEPOSITION TECHNIQUES

Thin Films – Introduction to Vacuum Technology - Deposition Techniques - Physical Methods –Resistive Heating, Electron Beam Gun, Laser Gun Evaporation and Flash Evaporations, Sputtering - Reactive Sputtering, Radio-Frequency Sputtering - Chemical Methods – Spray Pyrolysis – Preparation of Transparent Conducting Oxides.

UNIT IV: ZERO DIMENSIONAL AND ONE DIMENSIONAL NANO STRUCTURES

Synthesis of Metallic Nano Particles, Semiconductor Nano Particles and Oxide Nano Particles (homogeneous nucleation). Nano Particles by Heterogeneous Nucleus: Aero Sol Synthesis – Spray Pyrolysis.- anorods: Evaporation, Condensation Growth, Vapor-Liquid-Solid Growth, Electro Spinning – Lithography - Top down and Bottom up approaches- fullerenes- properties of fullerenes-Carbon Nano Tubes (CNTs)- Types, properties, synthesis and applications of CNTs.

UNIT V: CHARACTERIZATION TECHNIQUES

X – Ray Diffraction (XRD) – Powder and single crystal - Fourier Transform Infrared Analysis (FT-IR) – Elemental Analysis – Elemental Dispersive X-ray Analysis (EDAX) - Scanning Electron Microscopy (SEM) – UV-Vis-NIR Spectrometer – Etching (Chemical) – Vicker's Micro hardness.

BOOKS FOR STUDY:

1. Modern Physics- R. Murugeshan and Kiruthiga Sivaprasath, S.Chand and Company, New Delhi (2010).
2. Nuclear Physics - V. Devanathan, Narosa Publishing House, New Delhi (2008).
3. P. Santhana Ragavan and P. Ramasamy, Crystal Growth Processes and Methods, KRU Publications, Kumbakonam (2006).
4. A. Goswami, Thin Film Fundamentals, New Age International (P) Limited, New Delhi (1996).
5. Nanotechnology by S. Shanmugam (2010), MJP Publishers, Chennai.
6. Nanostructures and Nanomaterials by Guozhong Cao (2004), Imperial College Press, London.

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