

# Introductory course on Basic Astronomy and Astrophysics

Session: 2024 - 2025

The Astronomy Club of Bangabasi College Kolkata, India



**Duration:** 10 months in total, having 4/5 classes of around 1.5 hour duration (including interaction with students) per month (with a gap of two months for examinations). At least 50% of the classes will be conducted via online mode and would possibly be recorded. The rest will be held in offline mode at the college.

**Course In-Charge:** Dr. Partha Ghosh, Associate Professor in Physics, Bangabasi College, Kolkata

**Course-Coordinator:** Dr. Gourav Banerjee, Post-Doctoral Researcher, Indian Institute of Astrophysics, Bangalore

**Course Delivery Mode:** Classroom teaching, Discussion sessions, Hands-on activity cum Practical demonstration sessions, Star gazing nights, Seminar Talks by subject experts

**Eligibility:** Anyone studying in Bangabasi College with +2 level Mathematics and Physics background (may be relaxed under exceptional circumstances)

## Course Plan (Tentative)

Introduction to astronomy: its history and current status			
MONTH-1	Class-1	<b>Wonders of the Universe:</b> A journey through major astronomical objects and phenomena; our present understanding; importance of studying astronomy	G.B
	Class-2	Astronomical & Astrophysical Terminologies-1	P.G
	Class-3	<b>Astronomy during the early days:</b> Astronomy in ancient period; contributions of early philosophers such as Thales, Aristotle, Eratosthenes, Hipparchus, Ptolemy; Geocentric Universe concept	A.K
	Class-4	<b>Birth of Modern Astronomy:</b> Astronomy during medieval period; the Copernican revolution; contributions of Copernicus; Tycho Brahe, Kepler, Galileo, Newton; Heliocentric Universe concept, concept of celestial sphere	A.K
	Class-5	Astronomical & Astrophysical Terminologies-2	P.G
	Class-6	<b>Astronomy in India - Past, Present &amp; Future prospects:</b> Astronomy in ancient India; contributions of Aryabhatta, Bhaskara I and II; Kerala School of Astronomy; astronomy during 19 <sup>th</sup> and early 20 <sup>th</sup> centuries; present status; major institutes and universities; career prospects	G.B
	Class-7	Hands on Activity / Practical Session	P.G
Basic Physics for Astronomy and Astrophysics			
MONTH-2	Class-8	<b>Gravitation, Light and Matter:</b> Concept of Gravitation; Interaction between light and matter; EM spectrum; Blackbody Radiation; Wien's law; Stephan-Boltzmann law; Multi-Wavelength astronomy	P.G
	Class-9	<b>Fundamentals of Optics:</b> Reflection, Refraction, Interference, Diffraction, Polarization, Scattering & Dispersion; A hurricane tour	P.G
	Class-10	<b>Introduction to Special &amp; General Relativity:</b> Postulates of STR; Lorentz transformation; Concepts about space-time; Length Contraction, Time Dilation; Velocity Addition; Mass Energy Equivalence; Introduction to GTR; Idea about singularity	N.R
	Class-11	<b>Fundamentals of Nuclear &amp; Particle Physics:</b> Overview of the atomic nucleus; Forces and Models; Nuclear Reactions; Fission & Fusion, the Standard Model	P.G
	Class-12	<b>Atomic &amp; Molecular Spectroscopy Fundamentals;</b> Astrometry & Photometry techniques	P.G

<b>Astronomical Instruments</b>				
<b>MONTH-3</b>	<b>Class-13</b>	<b>Introduction to Telescopes and binoculars:</b> Working of telescopes; its types and parts; basic properties; telescope mounts, filters and eyepieces; professional telescopes and major observatories; working of binoculars; its properties	<b>G.B</b>	
	<b>Class-14</b>	<b>Practical demonstration Session:</b> Learn the working principles of reflecting and refracting telescopes, familiarity with binoculars, different telescope parts	<b>A.T/ P.G</b>	
	<b>Class-15</b>	<b>Modern instruments for Astronomy:</b> Development of larger telescopes since 18 <sup>th</sup> century; CCDs; photometers; spectroscopes; birth of Space age; Multi-Wavelength telescopes; Interferometry; Important Space Telescopes; Active and Adaptive optics	<b>G.B</b>	
	<b>Class-16</b>	Problem Solving Session I	<b>P.G</b>	
	<b>Class-17</b>	<b>Activity based Learning: Topic: Using astronomy software for sky watching;</b> Learning to use Stellarium / Cybersky apps and their applications	<b>A.K</b>	
<b>Introduction to the Solar System</b>				
<b>MONTH-4</b>	<b>Class-18</b>	<b>The Inner Solar System and Asteroid Belt:</b> Introduction to the Sun; its structure and major characteristics; terrestrial planets; their satellites; asteroid belt; types of asteroids; major missions to Inner Solar system objects	<b>K.C</b>	
	<b>Class-19</b>	Problem Solving Session III	<b>P.G</b>	
	<b>Class-20</b>	Hands on Activity / Practical Session	<b>P.G</b>	
	<b>Class-21</b>	<b>The Outer Solar System and Comets:</b> The Gas Giants; TNOs and Dwarf planets; their major satellites; Kuiper Belt and Oort Cloud; Comets, their types and properties; missions to outer Solar System	<b>K.C</b>	
	<b>Class-22</b>	Problem Solving Session IV	<b>P.G</b>	
	<b>Class-23</b>	Hands on Activity / Practical Session	<b>P.G</b>	
<b>Fundamental Stellar Astrophysics</b>				
<b>MONTH-5</b>	<b>Class-24</b>	<b>Introduction to stars and star clusters:</b> What is a star? fundamental properties: magnitude, distance, temperature, luminosity, radius, mass; energy generation in stars; types of star clusters	<b>G.B</b>	
	<b>Class-25</b>	Discussions on problems involving Stellar Physics	<b>P.G</b>	
	<b>Class-26</b>	<b>Types and classification of stars:</b> Binary and variable stars; their types, Cepheid variables and period luminosity relation; classification of stars: Harvard classification, M-K scheme; H-R diagram; Kirchhoff's laws, formation of spectral lines, optical spectra of stars: an introduction	<b>G.B</b>	
	<b>Class-27</b>	<b>Evolution of low mass stars:</b> Star formation; ISM; life-cycle of low mass stars: main sequence, red giant, planetary nebula and white dwarf phases	<b>G.B</b>	
	<b>Class-28</b>	Discussions on problems involving Stellar Evolution	<b>P.G</b>	
	<b>Class-29</b>	<b>Evolution of intermediate and high mass stars:</b> Life-cycle of intermediate and high mass stars: red supergiant, supernova, neutron stars, black holes; supernova nucleosynthesis; H-R diagram study; Supernova types; cosmic candles; discovery of the acceleration of the universe; Dark Energy	<b>G.B</b>	
<b>MONTH-6</b>	<b>Class-30</b>	<b>Activity based learning: Topic: Viewing the evolution of the Sun in the future:</b> Using the H-R diagram to determine how the Sun will evolve and die.	<b>G.B</b>	
	<b>Class-31</b>	Hands on Activity / Practical Session	<b>P.G</b>	
	<b>Galactic and Extra-Galactic Astronomy</b>			
	<b>Class-32</b>	<b>Milky Way and Beyond:</b> Concept of a Galaxy; structure of Milky Way; its neighbors; galaxy clusters and superclusters; rotation curve of galaxies: concept of Dark Matter; large scale structure of the universe	<b>SSH</b>	
	<b>Class-33</b>	Problem Solving Session V	<b>P.G</b>	
	<b>Class-34</b>	<b>Fundamentals of cosmology:</b> Birth of cosmology: Shapley Curtis debate, Hubble's observations and discovery; origin and evolution of the universe; Steady State and Big Bang models; concepts of Inflation; CMBR; birth of natural forces	<b>SSH</b>	
<b>Class-35</b>	Hands on Activity / Practical Session	<b>P.G</b>		

<b>Introduction to Exoplanets and Astrobiology</b>			
<b>MONTH-7</b>	<b>Class-36</b>	<b>Extra solar planets:</b> Discovery of exoplanets; their types and properties; Hot Jupiters and Super Earths; Habitable Zone; present status of exoplanets studies	<b>S.S</b>
	<b>Class-37</b>	<b>Basics of astrobiology:</b> What is astrobiology? Defining 'Life'; life on Earth: its origin and evolution; supernova types; cosmic candles; discovery of the acceleration of the universe	<b>G.B</b>
	<b>Class-38</b>	Problem Solving Session VI	<b>P.G</b>
	<b>Class-39</b>	<b>Practical demonstration session:</b> Citizen Science: contributing in professional astronomy being a non-professional.	<b>G.B</b>
	<b>Class-40</b>	<b>Activity based learning – Topic: Introduction to the Zooniverse platform</b> Learn how to participate in citizen science astronomy projects using the Zooniverse platform	<b>G.B/ TBA</b>
<b>Tools and techniques for Astronomy Research</b>			
<b>MONTH-8</b>	<b>Class-41</b>	<b>Databases and data searching tools in astronomy</b> Introduction to modern astronomical databases and catalogs: SIMBAD, Aladin, Vizier, Gaia DR3, NASA ADS	<b>G.B</b>
	<b>Class-42</b>	<b>Journals and papers in astronomy: an introduction</b> Introduction to research papers, research articles, authentic journals, indexing, citation, impact factor, h-index, ResearchGate	<b>G.B</b>
	<b>Class-43</b>	<b>Activity based learning - Topic: Introduction to the IRAF software</b> Learn to use the IRAF software Identify spectral lines in real spectra of stars Measure the SNR values and major spectral parameters – Equivalent width, FWHM	<b>G.B</b>
	<b>Class-44</b>	Hands on Activity / Practical Session: Variability of stars	<b>P.G</b>
	<b>Class-45</b>	<b>Activity based learning - Topic: Spectroscopic study using real stellar spectra</b> Identify spectral lines for hot variable stars using time series optical spectra Measure their period of variability and major spectral parameters Interpret the results to better understand the disc physics of certain exotic stars	<b>G.B</b>
	<b>CONCLUDING &amp; VALEDICTORY SESSION</b>		

**Note: Seminar Lectures by eminent Scientists in the field of Astrophysics-Cosmology would be arranged time to time, either in ONLINE or through physical mode. There would be provision for arranging outstation Star Gazing Nights also. Active participation of students in this regard is expected.**

#### **List of Reference Books:**

For basic astronomy as a beginner you can buy few books mentioned below. All these books are selected for recommendations taking into account the following important parameters:

1. Authentic information is presented without any / minor typo errors.
2. Written in popular style so that they can be understood by a layman
3. Availability is easy as most of them are available either online (Amazon) or in Kolkata International Book Fair.
4. The price for every book (except book no. 3) is below 1000/-

#### **General astronomy - Popular style:**

1. 50 Astronomy ideas you really need to know; Giles Sparrow; Quercus Publishing; Ed: 2016
2. 50 Universe ideas you really need to know; Joanne Baker; Greenfinch Publication; Ed: 2023

Both these are nicely written books to understand different basic concepts of astronomy and relevant physics. Hence, highly recommended.

3. Universe: The Definitive Visual Guide; DK; Ed: 2020; approx. 2000/-

A marvelous popular book with fantastic color pictures, though costly.

4. Astrophysics Simplified: A Simple Guide to the Universe; Madhur Sorout; Notion Press; 2019

A motivational book since it is written by a young school student.

5. Astronomy in minutes; Giles Sparrow; Quercus Publishing; 2015

A wonderful portable book where 200 key concepts about astronomy are explained in an instant. Suitable for any young child or also for any beginner.

### **Sky observation:**

1. The Joy of Star Watching; Biman Basu; National Book Trust (NBT); 2017

An easy to understand guide to identify almost every major constellation of each season.

2. Stargazing for Beginners; DK; Ed: 2020

Discover the wonders of the universe with this complete introduction to observing and understanding the night sky.

### **History of Astronomy:**

1. Cosmic Vistas; Biman Basu; National Book Trust (NBT);

Brief but really nice description about the history of astronomy written by a notable science communicator of India.

2. The Shortest History of the Universe; David Baker; Picador India; 2023

A captivating exploration through life, the universe and everything.

3. Story of Astronomy; Peter Aughton; Quercus Publishing; 2011

A detail book on history of astronomy.

### **Solar System studies:**

1. The Solar System in Minutes; Giles Sparrow; Quercus Publishing; 2018

An enjoyable book to know about 200 key concepts about the Solar System in popular style.

2. Solar System in Verse; Biman Nath; Niyogi Books; 2023

A unique asset where our Solar System has been magnificently described using poems by an eminent Indian astrophysicist, along with suitable illustrations.

3. Our Moon: a human history; Rebecca Boyle; Sceptre; 2024

A wonderful describing the importance of our Moon for the Earth and also in human life.

4. Mars: a celestial show's topper; Gourav Banerjee; Palmview Publishing; 2024

Another unique book which describes the thrilling true story of human exploration of space in a different style: how the overall knowledge about science and technology has progressed for two millennium just by exploring only one celestial object in the sky, i.e. the red planet Mars.

### **Stellar astronomy:**

1. What are the stars?; G Srinivasan; Universities Press; 2011

2. Can Stars Find Peace?;G Srinivasan; Universities Press; 2011

If you want to know about how stars work and evolve, i.e. basics of stellar astrophysics within only 500 pages, then you must read the above two books. Both are just unparallel. Although high school level mathematics is

used to explain the underlying physics, but those are well explained. One will definitely fall in love with stars if he/ she reads both these books from cover to cover.

### 3. The Hundred Greatest Stars; James B Kaler; Copernicus Books

A masterpiece written by an expert in stellar astrophysics. This iconic book describes the amazing properties of 100 selected stars of the sky - each important either historically, positionally or due to their beauty or strange properties. It can be considered as a rare asset for any sky lover.

#### **Cosmology:**

##### 1. Big Bang; Simon Singh; Harper Perennial; 2005

A wonderful account of the development of cosmology through ages written in lucid style.

#### **Astrobiology:**

##### 1. Astrobiology: A very short Introduction; David Cuttling; Oxford University Press

##### 2. Astrobiology: the search for life elsewhere in the universe; Andrew May; Icon Books; 2019

Both are enjoyable reads which introduces the subject in a popular manner.

#### **Dark Matter, Dark Energy and Gravitational waves:**

##### 1. Dark Matter and Dark Energy; Brian Clegg; Icon Books; 2019

##### 2. Gravitational Waves; Brian Clegg; Icon Books; 2018

A nice and robust introduction to the particular topics without using any mathematics.

#### **Space exploration:**

##### 1. India's Space Odyssey; DK; 2022

A nice book describing in brief about India's journey to space.

##### 2. Touching Lives; S K Das; 250/-

A fantastic account of how space technology development by ISRO has helped each and every human being of India. Must read.

##### 3. From Fishing Hamlet to Red Planet: India's Space Journey; ed: P V ManoranjanRao; Harper Collins; approx. 4500/-

A masterpiece book, however highly costly. It provides a detail description of how India has become a space power starting from zero.

#### **Astronomy career guide:**

##### 1. Becoming an astronomer; Gourav Banerjee; PalmView Publishing LLP; 2nd ed: 2018; 300/-

The first book of its kind published in India, it provides a detail guidance about how to become an astronomer. Particularly focuses on Indian perspective.

### **Some good popular astronomy books in Bengali**

#### **General astronomy:**

##### 1. প্রাথমিক জ্যোতির্বিজ্ঞান; Subhashis Chirokalyan Patra; Best Books; 150/-

A wonderful account about various basic concepts of astronomy. One of the must read books in astronomy written in Bengali.

### **Sky observation:**

1. গল্পে গল্পে আকাশ চেনা; Basudev Bhattacharya; Ananda Publishers; 300/-
2. তারা চেনার মজা; BimanBasu; NBT; 2019; 135/-

Both these are again beautiful books with authentic information.

### **History of telescopes:**

1. আকাশে মেলেছি চোখ; Goutam Gangopadhyay; Biva Publications; 199/-

Beautiful description about the history of development of telescopes and its contribution in understanding the universe in a better way.

### **Solar System:**

- 1 & 2. মহাবিশ্বের বিস্ময় 1 and 2; Arunava Chakravorty; Dey's Publishing; approx. 1000/-

Though both these books cover aspects of general astronomy, a meticulous description of Solar System objects make them must read for anyone who wants to better understand our Solar family.

### **Stellar astronomy:**

1. নক্ষত্রের গান; BimanNath; Ananda Publishers; 150/-

Written by an eminent astrophysicist, according to my knowledge, this can be considered as the best book on stellar astrophysics written in Bengali.

2. আমরা তারাদের অংশ; Amitabha Chakrovarty; Parchment; 240/-

A good account about birth and evolution of stars.

3. নক্ষত্রের সাথে কথা কয় পৃথিবীর প্রান; Biman Nath; শিশুসাহিত্য সংসদ; 350/-

A unique compilation depicting how different life forms in Earth are dependent on different cosmic objects and their movements across the sky for their living. This is a ne of a kind book which surely will take the readers to a never imagined world.

### **Galactic and extra-galactic astronomy:**

1. মহাবিশ্বের প্রথম আলো; Biman Nath; Anushtup Prokashoni; 150/-

An excellent account of the birth and evolution of galaxies written in easy language.

2. অশান্ত মহাবিশ্ব; BimanNath; শিশুসাহিত্য সংসদ; 400/-

Another engaging book providing details about various energetic cosmic phenomenon occuring in the universe.

### **Exoplanets:**

1. গ্রহ থেকে গ্রহান্তরে; SujanSengupta; Anando Publishers; 500/-

The only authentic and updated book on the study of extra solar planets and search for life outside Earth.

Written by a premiere exoplanetologist of India, this is a really good book.

### **Cosmology:**

1. মহাবিশ্বে মহাকাশে; Gouriprosad Ghosh; Baulmon Prakashan; 100/-

Undoubtedly the best book on cosmology written in Bengali. It was awarded 'Rabindra Smriti' puroshkar in 2001. Might appear bit tough for you.