# STUDY OF AMBIENT INTERSTELLAR MEDIUM AND ASYMPTOTIC GIANT BRANCH STARS AT DIFFERENT LATITUDES

**A Research Proposal**

Submitted to the University Grants Commision,
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By


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# Contents

# 1 Purpose

The proposed research work is entitled **"STUDY OF AMBIENT INTERSTELLAR MEDIUM AND ASYMPTOTIC GIANT BRANCH STARS AT DIFFERENT LATITUDES".**

# 2 Abstract

In this research work we will discuss how different physical parameters like flux, temperature, mass distributed near low intermediate mass star (0.8 - 8 $M_\odot$; LIMS) i.e. Asymptotic Giant Branch (AGB) stars. AGB stars are very important contributors of material to the interstellar medium (ISM), and yet the mechanisms by which this matter is expelled remain a mystery, temperature profile, shock nature of AGB star near cavity like structure plays a role in studying the interaction between ISM and AGB star at different latitudes. We will study using modern technologies and programs for the investigation different properties around AGB stars.

# 3 Background/Context/Problem

The interstellar medium in the vicinity of the Sun is arranged in large scale structures of bubble walls, sheets, and filaments of warm gas, within which close to the mid plane there are sub-sheets and filaments of cold dense material; the whole occupies roughly half the available volume and extends with decreasing mean density to at least a kilo parsec off the plane. The remainder of the volume is in bubble interiors, cavities, and tunnels of much lower density, with some but not all of those lower density regions hot enough to be observable via their X-ray emission. This entire system is pervaded by a rather strong and irregular magnetic field and cosmic rays, the pressures of which are confined by the weight of the interstellar gas, particularly that far from the plane where gravity is strong [1]. In thermodynamic equilibrium, a medium is characterized by a single temperature, which describes the velocity distribution, excitation, ionization, and molecular composition of the gas. While the velocity distribution of the gas can generally be well described by a single temperature, the excitation, ionization, and molecular composition are often very different from thermodynamic equilibrium values at this temperature. This reflects the low pressure of the ISM, so that, for example, collisions cannot keep up with the fast radiative decay rates of atomic and molecular levels. Ionization and chemical composition are also kept from their equilibrium values by the presence of $\sim$100 MeV cosmic-ray particles clearly a non-Maxwellian component and a diluted, stellar, EUV(10-124 nm) - FUV (100-200 nm) photon field, which is much stronger than a 100 K medium would normally have. Finally, the large-scale velocity field is much influenced by the input of mechanical energy. Whenever a gas is not in local thermodynamic equilibrium, the level populations, degree of ionization, chemical composition, and of course the temperature are set by balancing the rates of the processes involved. Much of the study of the ISM is thus concerned with identifying the various processes that control the ionization and energy balance, setting up the detailed statistical equilibrium equations and solving them for the conditions appropriate for the medium [2].

We intend to search suitable condition so that the interaction between AGB wind and ISM can be studied. In this research work we are focused on the how C-rich AGB star show behavior around their surroundings. Following are the valid problems of research

- It is believed that the shaping of infrared dust structure has a close relation with the inhomogeneous Interstellar Medium (ISM). The violent stellar phenomena lead inhomogeneity in the ISM. We intend to perform a multi wavelength study in the far infrared emission region. This may reveal the presence and role of hot phenomena (X-rays, gamma rays, etc) in the shaping process.
- A far infrared loops around ATNF Pulsars studied by A. K. Jha, B. Aryal & R. Weinberger (2017). There is lack of study such type of phenomenon in AGB star so I intend to study similar phenomena in AGB stars [3].
- Asymmetry mass ejection during the AGB phase was concluded by Zijlstra & Weinberger (2002), Aryal & Weinberger (2006), Aryal, Rajbahak & Weinberger (2009), Aryal, Rajbahak & Weinberger (2010) by studying dust structures around planetary nebula [4, 5, 6].

# 4 Literature Review

## 4.1 Interaction between ISM and the Stellar Wind

Many theoretical studies predict that the interaction of suitable stellar wind with the interstellar medium (ISM) creates "Interstellar Bubbles". One of the model proposed by Weaver *et al.* (1977) regarding the existence of interstellar bubble due to the interaction between stellar wind and homogeneous interstellar medium. Most of the theory presented below concerns with the following idealized model. At time t = 0, an early type star begins to blow a steady, spherically symmetric stellar wind with constant terminal velocity $V_w$ and mass loss rate $dM_w/dt$. The mechanical luminosity of $L_w$ of the wind is therefore given by

$$L_w = \frac{1}{2}\frac{dM_w}{dt}V_w^2 \tag{1}$$

This wind interacts with an ambient interstellar gas of uniform atomic density $n_0$ and given cosmic abundances, resulting in an expanding spherical system, which we shall call a bubble. Throughout it's evolution, the dynamical system consists of four distinct zones. Starting from within, they are: (a) the hypersonic stellar wind: (b) a region of shocked stellar wind: (c) a shell of shocked interstellar gas:

and (d) ambient interstellar gas. This structure is depicted schematically in Fig. (1) [7].
The evolutionary history of the bubble may be divided into three stages. At first, the bubble is expanding so fast that radiative losses in the gas do not have time to affect any part of the system, and the dynamics of each region is described by adiabatic flow. In the second stage, radiative losses cause the expanding shell of swept-up interstellar gas in region (c) to collapse into a thin shell; but region (b), the shocked stellar wind, still conserves energy. In the final stage, the radiative losses also affect the dynamics of region (b).

The structure of bubble during the first stage and the transition from first stage to the second stage have been considered by V. S. Avedisova and by S. A. E. G. Falle. They show that the first stage lasts a very short time; therefore, the structure during this first stage is of of somewhat academic interest. However, Weaver *et al*. shall review the problem since above discussions are not complete, and since the hydrodynamical solutions obtain may apply to a broader context than just the present model of a stellar wind interacting with interstellar gas. It is assumed that first region (c) of swept-up interstellar gas, whose outer boundary, at $R_2$, is a shock separating it from the ambient interstellar gas (d), and whose inner boundary, at $R_c$, is a contact discontinuity separating it from the shocked stellar wind (b). The structure of the region can be described by similarity solution. Here the theory of the adiabatic blast wave given by Weaver *et al*.[7] assumed that the energy is fed into the system at a constant rate instead of in an initial blast [7].

Weaver *et al*. (1977) neglecting gravity assumed that the flow is spherically symmetric, and find the equations of motion and continuity are equations describes the dynamics of interstellar medium can be described by the continuity, momentum, and energy equations [7].

## 4.2 Inhomogeneity

Segregation of the matter into cold and warm components is not the only source of inhomogeneity in the ISM. In this section we consider the arm/interarm contrast, the observations indicating that there are large cavities and tunnels of very low density in the ISM and observed distribution of the denser matter. The interstellar medium is expected to have a certain amount of large-scale inhomogeneity just from dynamical events [1].

To study the properties such as inhomogeneity of ISM and AGB wind we must define some of the terms like source term in R.H.S. of expression. Without neglecting gravity and we assume that the flow is asymmetric, the equations of motion is inhomogeneous and discontinuity. This term is either defined as four dimensional tensor which includes space and time both or simply impulse as:

$$\frac{\partial v}{\partial t} + v\frac{\partial v}{\partial r} + \frac{1}{\rho}\frac{\partial p}{\partial r} = f(r,t), \tag{2}$$

and

$$\frac{\partial \rho}{\partial t} + v\frac{\partial \rho}{\partial r} + \rho\frac{\partial v}{\partial r} + 2\frac{\rho v}{r} = f(r,t). \tag{3}$$

The equation of energy conservation for the adiabatic flow during this stage is

$$\frac{D}{Dt}(p\rho^{-\gamma}) = f(r,t), \tag{4}$$

Where,
$\frac{D}{Dt} = \frac{\partial}{\partial t} + v\frac{\partial}{\partial r}$ and $\gamma = \frac{5}{3}$, the equation of energy conservation for the adiabatic flow may other types of flow there during this stage equation can be written is in the form

$$\frac{D}{Dt}(p\rho^{-\gamma}) = f(r,t), \tag{5}$$

Where,
$\frac{D}{Dt} = \frac{\partial}{\partial t} + v\frac{\partial}{\partial r}$ and $\gamma = \frac{5}{3}$.

As the equation

$$\Box^2_{x,t}\Psi(\vec{X},t) = f(\vec{X},t) \tag{6}$$

Where, $\Box^2_{x,t} = \nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}$ is called is D'Alembertian. We wish to solve the equation

$$(\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2})G(\mathbf{X}-\mathbf{X}', t-t') = -\delta(\mathbf{X}-\mathbf{X}', t-t')\delta(t-t') \tag{7}$$

Where, $G(\mathbf{X}-\mathbf{X}', t-t')$ is the solution of equation (7) and $\delta(\mathbf{X}-\mathbf{X}') = \delta(x-x')\delta(y-y')\delta(z-z')$ is called Dirac Delta function and The mathematical detailed is not mentioned here but in shortly the solution of equation (7):

$$G(\mathbf{X}-\mathbf{X}') = -\frac{c}{4\pi|\mathbf{X}-\mathbf{X}|}[\delta[(|\mathbf{X}-\mathbf{X}'|-c(t-t')]-\delta[(|\mathbf{X}-\mathbf{X}'|+c(t-t')] \tag{8}$$

Here, the Green's function with first delta function, i.e.,

$$G(\mathbf{X}-\mathbf{X}') = -\frac{c}{4\pi|\mathbf{X}-\mathbf{X}|}\delta[(|\mathbf{X}-\mathbf{X}'|-c(t-t')] \tag{9}$$

is called the retarded or causal Green's function because the source point time $t'$ is always earlier than the observation point time $t$ which describes how causality is conserved, i.e. effect after cause and used for positive time particle. The Green's function

$$G(\mathbf{X}-\mathbf{X}') = \frac{c}{4\pi|\mathbf{X}-\mathbf{X}|}\delta[(|\mathbf{X}-\mathbf{X}'|+c(t-t')] \tag{10}$$

is called advanced Green's function which violets causality, i.e., effect before cause and used for negative time particle called antiparticle.
In similar manner in electromagnetic field

$$\partial_\alpha F^{\alpha\beta} = \frac{4\pi}{c}J^\beta \tag{11}$$

With the definition of the fields in terms of the potentials this becomes

$$\Box A^{\beta} - \partial^{\beta}(\partial_{\alpha} A^{\beta}) = \frac{4\pi}{c} J^{\beta} \tag{12}$$

If the potential satisfy the Lorentz condition, $\partial_{\alpha} A^{\beta} = 0$, the four-dimensional wave equation in covariant form:

$$\Box A^{\beta} = \frac{4\pi}{c} J^{\beta} \tag{13}$$

Using Green function method we intended to solve many inhomogeneous issues encounter in interstellar medium. The differential equations encountered in physical problems are not always homogeneous.[8] If either the differential equation or boundary conditions or both are non-homogeneous, the boundary value problem is called non-homogeneous. The method of Green's function is convenient technique for such problems. In 1828 George Green (1793 - 1841) published an essay on the application of mathematical Analysis to the theory of Electricity and magnetism. In this seminal work of mathematical physics, Green sought to determine electric potential with in a vacuum bounded by conductors with specified potentials [9]. Here in ISM and AGB wind interaction case there is also the asymmetry, i.e., symmetry breaking also the ISM is not in LTE (Local thermodynamic Equilibrium) which violates the symmetry and LTE. In our region of interest there is huge variation of density near the cavity there is less dense which disturb the LTE.

## 4.3 Ambient Interstellar Medium

The interstellar medium in the vicinity of the Sun is arranged in large-scale structures of bubble walls, sheets, and filaments of warm gas, within which close to the mid-plane there are sub sheets and filaments of cold dense material; the whole occupies roughly half the available volume and extends with decreasing mean density to at least a kilo parsec off the plane. The remainder of volume is in bubble interiors, cavities, and tunnels of much lower density, with some but not all of those lower density regions hot enough to be observable via their X-ray emission. This entire system is pervaded by a rather strong and irregular magnetic field and cosmic rays, the pressures of which are confined by the weight of the interstellar gas, particularly that far from the plane where gravity is strong. Observations suggest that the cosmic rays and magnetic field have an even more extended vertical distribution than the warm gas, requiring either the weight of additional coronal material or magnetic tension confine it to the disk. Adjusting one's perception of this medium to embrace the known aspects is difficult. After this adjustment, there are many problems to solve and prejudices to overcome the weak role of thermal instability, the suppression of certain gravitational instabilities, the problem of determining the state in a low-density regions, the twin difficulties of not having too much OVI ($O^{+5}$) and getting enough diffuse 3/4 KeV, X-ray emission, the possible importance of large old-barrel shaped supernova remnants in clarifying matters, the possible role of dust evolution in adjusting the heating to make clouds stable, the factors influencing the magnitudes of the interstellar pressure and scale height things that global models of the medium might examine to clarify some of these matters; attention to these details and more constitute the challenge of this subject.

### 4.4 Asymptotic Giant Branch Phase

Our knowledge of the AGB phase of evolution has increased dramatically over the last 2 decade or so, driven primarily by observations. Theoretical studies are desperately needed to quantify the nucleosynthesis which occurs in intermediate mass stars during their thermally pulsing evolution. A period of stellar evolution undertaken by all low to intermediate mass stars (0.8 - 8 solar masses) late in their life is called Asymptotic Giant Branch (AGB) phase. The structure of a star when it reaches the AGB is characterized by: (i) a small, very hot and dense core of carbon and oxygen; (ii) He- and H- alternately burning shells; (iii) a large, hot, and less dense stellar envelope; (vi) a warm atmosphere and a very large, diluted and cool circumstellar envelope. for stars with masses between about 1 and 8 $M_\odot$ the ascent of the AGB is the last nuclear powered evolutionary stage. Although only short in duration, the AGB is very important due to the nucleosynthesis which occurs.
The asymptotic giant branch (AGB) is the region of the Hertzsprung-Russell diagram populated by evolving low- to medium-mass stars. This is a period of stellar evolution undertaken by all low- to intermediate-mass stars (0.6 - 10) $M_\odot$ late in their lives. Asymptotic giant branch (AGB) stars are generally classified as oxygen-rich (M-type) or carbon-rich (C-type) based on the chemistry of the photosphere and or the outer envelope [10].

## 5 Theoretical/Technical Aspect

### 5.1 Dust Color Temperature Estimation

There are many model for calculation of temperature with the help of different data base. In this sort of dissertation work we use data base from the IRAS 60 $\mu$m and 100 $\mu$m flux densities is similar to that of Schnee *et al*. (2005) [11]. By knowing the flux densities at 60 $\mu$m and 100 $\mu$m, the temperature contribution due to dust color can be calculated. The dust temperature $T_d$ in each pixel of a FITS (Flexible Image Transport System) image can be obtained by assuming that the dust in a single beam is isothermal and that the observed ratio of 60 $\mu$m to 100 $\mu$m emission is due to black body radiation from dust grains at $T_d$, modified by a power law of spectral emissivity index. The flux density of emission at a wavelength $\lambda_i$ is given by

$$F_i = \left[\frac{2hc}{\lambda_i^3(e^{\frac{hc}{\lambda_i K T_d}} - 1)}\right] N_d \alpha \lambda_i^{-\beta} \Omega_i \tag{14}$$

where, $N_d$ is the column density of dust grains, $\alpha$ is a constant which relates the flux with the optical depth of the dust, $\beta$ is the spectral emissivity index, and $\Omega_i$ is the solid angle subtended at $\lambda_i$ by the detector. Following Dupac *et al.* (2003)[12], we use the equation

$$\beta = \frac{1}{(\delta + wT_d)} \tag{15}$$

to describe the observed inverse relationship between temperature and emissivity spectral index. Here, $\delta$ and $\omega$ are fee parameters found that the temperature dependence of the emissivity index fits very well with the hyperbolic approximating function [12].
Considering temperature as an independent variable, the best fit gives $\delta = 0.40 \pm 0.02$ and $\omega = 0.0079 \pm 0.0005$ K$^{-1}$, with the $\chi^2$/degree of freedom = 120/120. With the assumptions that the dust emission is optically thin at 60 $\mu$m and 100 $\mu$m and that $\Omega_\omega \simeq \Omega_{100}$ (true for IRAS image), we can write the ratio, R, of the flux densities at 60 $\mu$m and 100 $\mu$m as

$$R = 0.6^{-(3+\beta)} \left[ \frac{e^{\frac{144}{T_d}} - 1}{e^{\frac{240}{T_d}} - 1} \right] \tag{16}$$

The value of $\beta$ depends on dust grain properties as composition, size, and compactness. For reference, a pure blackbody would have $\beta = 0$, the amorphous layer-lattice matter has $\beta \sim 1$, and the metals and crystalline dielectrics have $\beta \sim 2$.

For a smaller value of $T_d$, 1 can be dropped from both numerator and denominator of equation (16) and it takes the form

$$R = 0.6^{-(3+\beta)} \left[ \frac{e^{\frac{144}{T_d}}}{e^{\frac{240}{T_d}}} \right] \tag{17}$$

Taking natural logarithm on both sides of equation (2.50) we find the expression for the temperature as

$$T_d = \frac{-96}{ln\{R \times 0.6^{(3+\beta)}\}} \tag{18}$$

where R is given by

$$R = \frac{F(60\mu m)}{F(100\mu m)} \tag{19}$$

F(60 $\mu$m) and F(100 $\mu$m) are the flux densities at 60 $\mu$m and 100 $\mu$m, respectively. In this way we can use equation (18) for the determination of the dust grain temperature.

## 5.2 Mass Estimation

Since the longer wavelength measurements give us more precise dust masses due to the characteristics of Planck curve, the far infrared emission which is used for the derivation of dust mass is measured from the 100 $\mu$m IRAS images. The dust masses are estimated from the IR flux densities [13].

In order to estimate the dust masses from the infrared flux densities at 100 $\mu$m, following the calculation of Young *et al.*[14] we need the background correction of flux and convert the relative flux into absolute flux. The background correction is done by subtracting the average flux emitted by the external sources other than the object of interest. The black body intensity can be calculated using the basic expression as given in equation (22). The resulting dust mass depends on the physical and chemical properties of the dust grains, the adopted dust temperature $T$ and the distance $D$ to the object.

$$M_{dust} = \frac{4}{3}\frac{a\rho}{Q_\nu}\left[\frac{S_\nu D^2}{B(\nu, T)}\right] \tag{20}$$

where,
$a$ = weighted grain size
$\rho$ = grain density
$D$ = Distance to the star
$Q_\nu$ = grain emissivity
$S_\nu$ = f $\times$ MJy/Sr $\times$ 5.288 $\times$ $10^{-9}$

**For 100 $\mu$m emitter**
$a$ = 0.1 $\mu$m
$\rho$ = grain density =3000 kg m$^3$ , Q$_\nu$ = grain emissivity = 0.0010 (for 100 $\mu$m)
Q$_\nu$ = grain emissivity = 0.0046 (for 60 $\mu$m) [14]
$S_\nu$ = f $\times$ MJy/Sr $\times$ 5.288 $\times$ $10^{-9}$
where, 1 MJy/Sr = 1 $\times 10^{-20}$ kg s$^{-2}$ and f = relative flux density measured from the Groningen IRAS image[15].
For 100 $\mu$m wavelength, the expression for the dust mass reduces to,

$$M_{dust} = 0.40\left[\frac{S_\nu D^2}{B(\nu, T)}\right] \tag{21}$$

The Planck's function is a well known function, given by this equation,

$$B(\nu, T) = \frac{2h\nu^3}{c^2}\left[\frac{1}{exp(\frac{h\nu}{KT}) - 1}\right] \tag{22}$$

Where,
$h$ = Planck's constant
$c$ = velocity of light
$\nu$ = frequency at which the emission is observed

$T$ = Temperature of each pixel

It is clear from the expression (22) that the value of Planck function B ($\nu$, T) for longer wavelength is higher than that of the shorter wavelength. Consequently, the range of B ($\nu$, T) for fixed temperature (say $\Delta$T) goes narrower if wavelength of the images increases [14].

# 6 Significance of the Development/Innovation

An interesting result obtained by Jha *et al.* (2017) from the study of far infrared loop-like structures (KK-loops) in 100 and 60 $\mu$m IRAS maps which are identified by Kiss et al. (2004) and Koenyves et al. (2007). They reported 462 far infrared loops. In the study of KK-loop G007+18 is $2.2° \times 2.1°$ (Koenyves et al. 2007) whereas its core size is $0.9° \times 0.4°$. Therefore the core region of this loop is only $\sim 8\%$ of the whole loop. An extended principle minima can be seen in the central region (Fig. 2 a). The dust color temperature ($T_d$ hereafter) calculated using the slope of $F(100)$ and $F(60)$ plot (Fig. 2 b) is found to be minimum, i.e., 20.1±1.1K. The minimum and maximum value of $T_d$ is found to lie in the range 19.1±1.1K and 20.8±1.2K. An offset of $<$ 2K suggests that the core of the loop is stable. The minimum temperature region is found to be elongated along north-south direction (Fig. 2 c). The dust mass contours (Fig. 2 d) seem to follow the expected trend: higher density at low temperature region. The distribution of dust color temperature fits well with Gaussian (Fig. 2 e) with Gaussian center at 19.9K. The value of $T_d$ of the larger structure is found to be 33.0±2.1K. Therefore the cavity is cold (low density) enough at the core region than that of the outer region. As a whole, an offset of 15 K temperature suggest that the cavity is dynamically active. The inclination angle of its core (area $\sim$ 0.36 square degree) is found to be 83° (edge-on) whereas it is 25° (face-on) as a whole (area $\sim$ 4.6 square degree). Jha *et al.*(2017) concluded that the inner region of KK-loop G007+18 is found to be oriented by about 58$\sim$60° (assuming the loop is in the sky plane). It means that our dusty loop is neither face-on ($i \to 0°$) nor edge-on ($i \to 90°$) [3].
Another result obtained by Aryal *et al.* (2010) suggested that different structures described are physically related to NGC 1514 and can be put in chronological order: the roundish nebula is the fossil remnant of the spherically symmetric outflow in the AGB phase. The outer bipolar structure marks the first (massive) aspherical outflow in the PPN phase, later followed by a second one (the inner bipolar structure), which took place along an other axis due to precision. Later, the PN formed and was partly shaped by the effects of the earlier dusty outflows as indicated by its brightness depression along the same axis as the inner bipolar structure. These collimated outflows could have been driven by the hot compact central star. To sum up, NGC 1514 and its surroundings could represent the preserved history of the main mass-loss phases of a star of intermediate initial mass [6].

Aryal *et al.* (2010) mentioned in paper Typical wind velocities in the AGB phase are 10 - 20 km $s^{-1}$. To cover the angular distance of 0.4° (i.e. 1.29 pc at D = 185 pc) with a constant velocity of 15 km $s^{-1}$ takes $8.4 \times 10^4$ years. In this way it is concluded that this is approximately the time when the strong spherical AGB mass loss started; its material is now visible as the roundish nebula of dust emission. In the short (typically $\sim$ 1000 years) phase of transformation from spherical mass loss into an aspherical nebula, the outer structure (A - A') in Fig. 2A was generated; it may contain entrained material from the AGB wind [6].

# 7 Foundational/ Preliminary Work

I have supervised two M.Sc. Project Works related to AGB stars and nine B.Sc.Project Works related to AGB stars, Nebulae and Moon Craters. Now five B.Sc.Project Works, two M.Sc. project works and one M.Sc. thesis with collaborations and myself are in pipeline. I hope this grant strengthen our research works.

# 8 Development/Innovation Goal/ Objectives

After the completion of research work, it is expected to discover cavity or nebular like structures. Further, dust color temperature, intensity variation and mass profile of the structure will be studied. The interaction between different AGB stars in interstellar medium will be studied. We also interested to interpret different shock wave ejected by far infrared loops wind with inhomogeneous nature and want to introduce Greens function technique for solving such problem. The research will be submitted to the University Grants Commission, Sanothimi Bhaktapur, Nepal.

- **Quality Education:** We realized the need of this research as we found most of our under-graduate and graduate students lacking in research skills which is needed for their career in science and physics. We believe, it will be able to help our undergraduate and graduate students to develop their research skills at the end of research work.

- **Gender Equality:** Few female students are interested to do research in Astrophysics and Astronomy in our departments and hence this grant help us and them to provide more access towards research opportunities in Nepal.

- **Innovation:** We believe the computational skills we will develop during the research help us and students become innovative and think of more research engagement in future.

Following are the major objectives of this work:

- To investigate the new isolated cavity structure including cavity in IRAS, IRIS, AKARI and 2MASS maps by performing a systematic search in all wavelength band in the these surveys of C-rich, O-rich and Si- rich AGB stars catalog.

- To know the model of cavity formation due to AGB wind, we intend to study the flux density, dust color temperature, intensity variation, dust-grain mass distribution, outflow nature and associated energy of the structure.
- To estimate Shock nature, i.e., C-shock and J-shock[2] ejected by AGB wind. By knowing inhomogeneous nature of medium we will try to correlate or interpret in term of Green's function technique.

# 9 Design / Methodology and Verification

## 9.1 Research design

We are planing to perform this research with the help of data provided by Infrared Astronomical Satellite Survey(IRAS), Improved Reprocessing of the IRAS Survey (IRIS), AKARI and 2MASS data using Set of Identifications, Measurements and Bibliography for Astronomical Data (SIMBAD) [17, 18]. We have plan to conduct this research work at computational laboratory of Amrit Cam- pus, Thamel, Kathmandu, Nepal. So, the fund provided will be used to upgrade the computer system provided in Amrit Campus, Thamel, Kathmandu Nepal at computa- tional laboratory. Data will be processed by using Aladin, Python, Origin, and Octave softwares among which we plan to buy with the fund provided to us. We will adopt following procedures in order to carry out proposed work:

## 9.2 Infrared Astronomical Satellite Survey

IRAS was a joint project of the US, UK and the Netherlands. For ten months in 1983, the Infrared Astronomical Satellite (IRAS) scanned more than 96 % of the sky. IRAS discoveries included a disk of dust grains around the star Vega, six new comets, and very strong infrared emission from interacting galaxies as well as wisps of warm dust called infrared cirrus which could be found in almost every direction of space. IRAS also revealed for the first time the core of our galaxy, the Milky Way.
Aladin v2.5 and Aladin v9 are an interactive sky atlas developed and maintained by the Center deDonne's astronomiques de Strasbourg (CDS) for the identification of astronomical sources through visual analysis of reference sky images. Aladin v2.5 and Aladin v9 allows the user to visualize digitized images of any part of the sky, to superimpose entries from the CDS astronomical catalogs and tables, and to interactively access related data and information from SIMBAD, NED or other archives of all known objects in the field.

## 9.3 Spitzer Survey Telescope

The Spitzer Space Telescope was launched on August 25, 2003. Spitzer is the final mission in NASA's Great Observatories Program. During the 5.5 year cryogenic mission, Spitzer made spectral and photometric observations between wavelengths of 3 and 180 microns. Imaging at 3.6 and 4.5 microns continues during the ongoing Spitzer Warm Mission. IRSA serves all Spitzer data from both the cryogenic and warm missions through the Spitzer Heritage Archive (SHA). In addition, IRSA serves enhanced data products from Spitzer Legacy programs.

# 10 Expected Product

Our research interests lie in astronomy and astrophysics. We have a small group continuously working on several topic. Basically our researches concern about the "STUDY OF INTERSTELLAR MEDIUM AND ASYMPTOTIC GIANT BRANCH STARS AT DIFFERENT LATITUDES" and main focus of this project is to motivate students for research activities. The major expected output of this project will be as follows:

- I will supervise at least one Master student and two bachelors students (project works).
- If possible, We will try to publish at least one high impact factor peer-reviewed international and one national journals.

# 11 Limitations and Delimitations

## 11.1 Limitations

- Search for any stellar objects which might be capable of shaping an interstellar cloud of small or moderate mass; such an object should be located at or around the extended emission[6]. With SIMBAD, We intend to investigate discrete sources in the field of the infrared emission that might be responsible for cavity formation near AGB star.
- Few Physicist are doing research in the field of Astronomy and Astrophysics in our country. So it helps to promote Young researchers by doing research in different field using more advanced softwares.
- A study Shock nature, i.e., C-shock and J-shock ejected by AGB wind for understanding inhomogeneous nature of medium, mathematical methods may be developed.

## 11.2 Delimitations

Even many genuine softwares are required to investigate the other parameters like velocity, energy, and distances they are more expensive for eg cost of Matlab software is USD 2,350 for Perpetual license and hence making some collaboration from the other research institute abroad, we can carry out the investigations for various parameters.

## 12 Ethical/Safety Issues

Our study will be original and based on the simulation and computational study which may not be harmful to human beings. We will maintain the copyright properties and if it will be necessary to use then we will use it with prior permission with acknowledgment.

## 13 Organization of the Final Report

We have plan to conduct this research work at computational laboratory of Amrit Campus, Thamel, Kathmandu, Nepal. So, the fund provided will be used to upgrade the computer system provided in Amrit Campus, Thamel, Kathmandu Nepal at computational laboratory. Data will be processed by using Python, Origin, Matlab, and Octave softwares among which we plan to buy with the fund provided to us. We will adopt following procedures in order to carry out proposed work:

**Table 1:** The estimated time schedule for the research is presented as follows:

| **Work/ Time(Months)** | **2 Mon.** | **4 Mon.** | **6 Mon.** | **8 Mon.** | **10 Mon.** | **12 Mon.** |
|---|---|---|---|---|---|---|
| **Literature Review** | ■ | ■ | | | | |
| **IRAS/IRIS AKARI/2MASS Survey Map for isolated structure** | | ■ | | | | |
| **Problem Identification** | | ■ | ■ | | | |
| **Image production & Analysis through different Softwares** | | | ■ | ■ | | |
| **Simulation** | | | | ■ | | |
| **Modeling: Theory** | | | | ■ | ■ | |
| **Interpretation & first draft** | | | | | ■ | |
| **Review & correction** | | | | | ■ | ■ |
| **Finalizing & Submission** | | | | | | ■ |

# 14 Grant Chart and Detailed Budget

**Table 2:** The expected budget for the proposed research program has been estimated as follows:

| **S.N.** | **Particulars** | **Estimated Budget (Rs.)** |
|---|---|---|
| 1. | Reference Books/Journals/Documents and Stationary | 15,000 |
| 2. | Library fee | 10,000 |
| 3. | Scientific tools, genuine software | 20,000 |
| 4. | Communication and Internet | 20,000 |
| 5. | Travel and conference Costs | 50,000 |
| 6. | Printing and Binding | 20,000 |
| 7. | Publications | 10,000 |
| 8. | Miscellaneous | 5,000 |
| | **Total (Rs.)** | 1,50,000 |

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# 15 Association to National Priority

Following are main association to National Priority of proposed research:

- Although globally Astrophysics and Astronomy is highly emerging subject for research and innovation but in context to our country there is lack of the study in research point of view in the concerning field.

- To know about Stellar structure and evolution to, on, and past the AGB.

- To know about Nucleosynthesis, concept of carbon nanotubes in space.
- To know about Pulsation, dynamical atmospheres and dust formation.
- To study Physics of circumstellar envelopes of AGB stars and their progeny.
- To study about Galaxy evolution, including the first AGB stars.