Low Frequency imaging of HESSJ1640-465 and HESSJ1804-216

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Abstract

The High Energy Stereoscopic System (H.E.S.S.) has made the first sensitive survey of the inner part of our Galaxy at TeV energies and has revealed a new class of high energy emitting sources. The multi-wavelength studies are useful to investigate and model supernovae, supernova remnants and HII regions to yield important constraints on the evolution of the supernova remnants. We carried out a very low frequency radio survey with the Giant Metrewave Radio Telescope (GMRT) on a few HESS sources to discover their radio characteristics. Most of these sources are associated with supernova remnants. During our survey, HESS J1640-465 and HESS J1804-216 were positively detected at 610MHz. These are Type II supernovae with a shell type morphology. We present in detail their spectral and morphological information, along with a discussion on possible counterparts at other wavelenghts.

Observation and Analysis

The radio observations were performed on HESS J1640-465 and HESS J1804-216 with the GMRT on March, 18th 2006 at 610 and 235MHz. The data was analyzed using AIPS software. During first few hours of our observations, we experienced three power failures when only central square (twelve) antennae were available for mapping. Thus we have failed to obtain a better image at 235MHz due to missing visibilities. The noise in the data is high due to power failures. In this poster we only present our data at 610MHz.

	151	235	325	610	1420
Primary Beam (arc min)	186+/-6	114+/-5	81+/-4	43+/-3	24+/-2*(1400/f)
Synthesised Beam (arcsec) Whole Array	20	13	9	5	2
Best rms sensitivies achieved so far as known to us (mJy)	1.5	0.6	0.3	0.02	0.03

The H. E. S. S. and GMRT telescope array are shown below. The positional accuracy of H.E.S.S. is 1 arcmin (2 sigma).

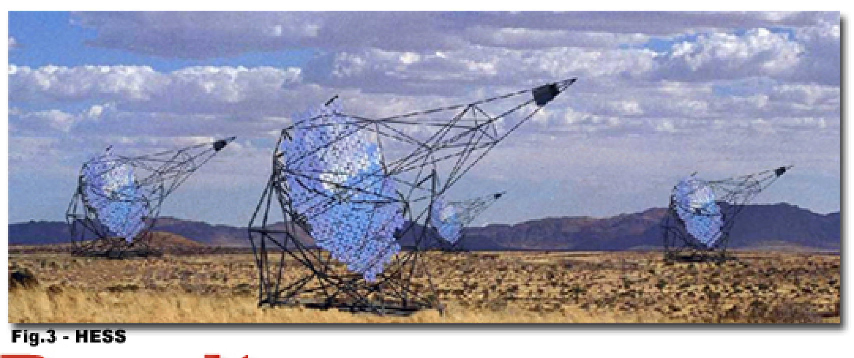

Fig.3 - HESS

Fig.4 - GMRT

Introduction

A Supernova Remnant (SNR) is a cataclysm, it is the end of life of a star with at least two possible ways to their formation. The first one is a thermonuclear explosion of a white dwarf giving birth to Type I SN. It is an explosion triggered by the accumulated material from a companion star. The second route is the gravitational collapse of a massive star, i.e. the heart collapse resulting in the formation of pulsars, Pulsar wind nebule (PWNs) and giving rise to Type II SNRs. These remnants emit non thermal (synchrotron) radio emission. Pulsars are highly magnetized and act like unipolar inductors accelerating particles. The pulsar wind interacts with the ambient medium, generating a shock region where particles are accelerated. These accelerated electrons are emitting at very high energy and are injected in the ISM where they energize the medium (ref. fig. 1).

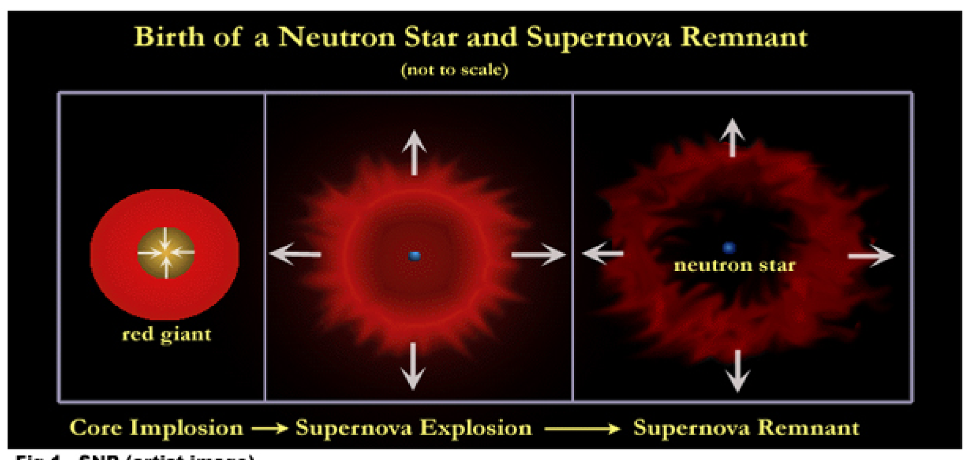

Fig.1 - SNR (artist image)

The supernovae and interstellar wind/dust form a dense cloud of molecular region giving birth to HII region. It is a dense region of molecular hydrogen. In this region, we can see different concentrations of new born stars, according to the size. With the birth of new stars, the temperature of the cloud gets up enough to ionize gas to produce atomic hydrogen and create an ionisation front or a HII region. The cloud of warm dust is emitting at infrared wavelengths and the emission from the HII region is thermal in origin. These regions can be extended by one to several hundreds of years lights in the universe and its lifetime is in the order of a few million years.

In figure 2, we show an example of a radio image of SNR W30 observed at 90cm by the Very Large Scale Array of Telescope (VLA). The non thermal sources in these images are primarly blue in color, while massive star forming regions composed of thermal ionized hydrogen gas are white; warm thermal dust emission is red.
Type II SN i.e. shell-type SNRs, are widely assumed to be the source of the Cosmic Rays (CRs). The acceleration of particles to CR energies is assumed to occur at the outer quasi-spherical shock which also compresses and heats the ambient medium. The expanding shock confines the accelerated particles in its interior until its velocity decreases. Then the shock gets 'old' and the more energetic particles successively leave the remnant. The collision of these energetic particles with the CR gives rise to gamma-ray emissions as imaged by H.E.S.S., which are mainly due to pion decay and the Inverse Compton radiation (IC) originating from the local source.

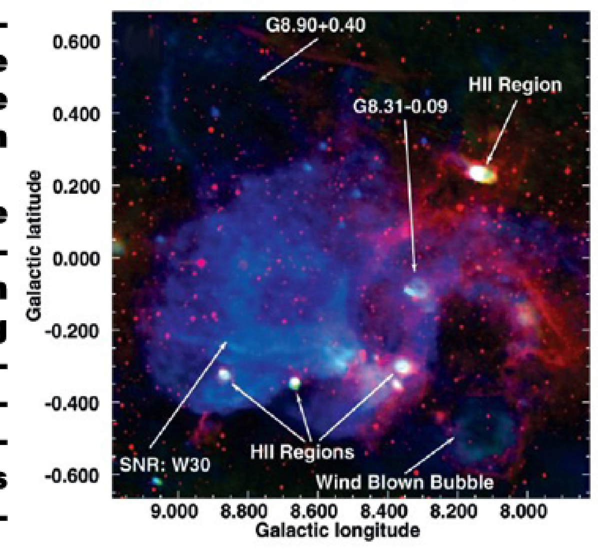

Fig.2 - SNR (VLA image 90cm)

Results

-HESS J1640-465

HESS J1640-465 is marginally extended with respect to the Point Spread Function (PSF) of the H.E.S.S. instrument. The very high energy source is spatially correlated to the radio SNR (G338.3+0.0) with a broken shell lying at the edge of a bright HII region briding this SNR to SNR (G338.5+0.1). The radio data on this source from Molonglo catalogue shows a shell type structure at 843MHz.

The radio image of HESS J1640-465 at 610MHz is shown below. We can see that the source is a SNR with a double source in the center as observed by the GMRT. The radio flux densities of the various components are listed in the table below. The left arm of the SNR is more intense, suggesting that the matter emitting synchrotron radiation are carrying more energy in that direction. The arm appears to be flattened due to pressure it experiences from the Inter Stellar Medium (ISM). On comparison with the radio data at other frequencies, we observed an increase in the size of the source at lower frequencies. The size of the source is significantly large (8 arcmin), suggesting that either it is an old SNR or it is very near in distance in our galaxy. The double source in the center of the SNR is not identified as an extragalactic source from the NASA Extragalactic Database. It is an unknown source in the field center. We have determined six known field sources within the position uncertainity circle of the HESS source. These counterparts are mainly emitting at very high energy.

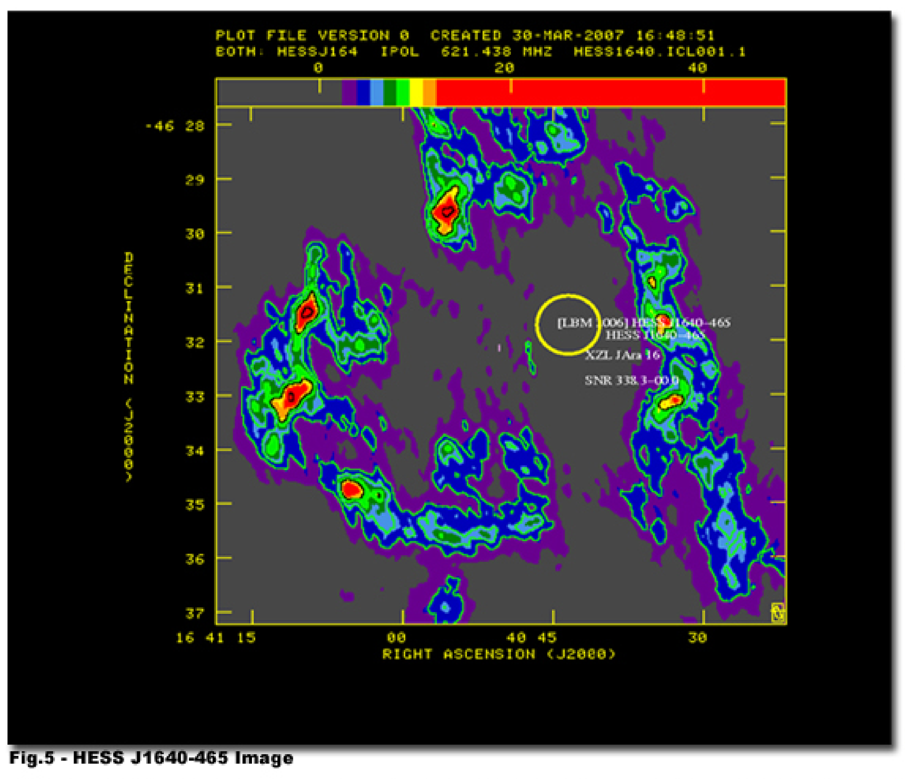

Fig.5 - HESS J1640-465 image

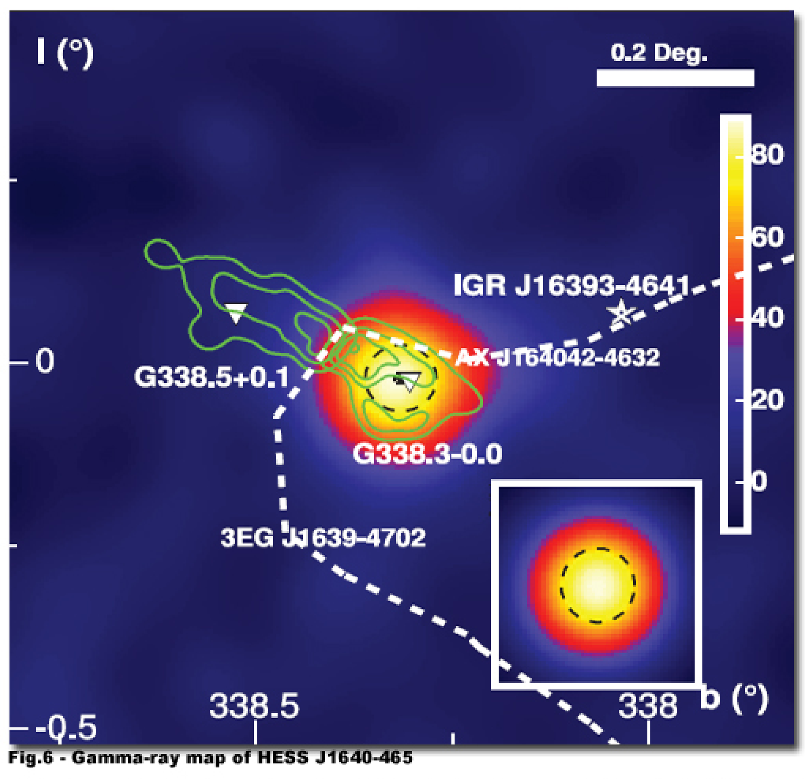

Fig.6 - Gamma-ray map of HESS J1640-465

Comparing the gamma-ray and the radio images we can see that there are already known EGRET and INTEGRAL sources discovered in this region, suggesting that it is an active region. It is also very interesting to note that the size of the source at radiowavelengths is four times larger than at gamma-ray wavelengths. This may suggest that the gamma-ray emissions are initially detected while the source is still a 'young' SNR and the very high energy particles escape the expanding SN cloud, whereas, the radio emissions are emitted later when the source expands while emitting at lower wavelengths with the decay in energy.

-HESS J1804-216

This source is associated with a SNR (G8.7-0.1) and a pulsar (PSR J1803-217). It may be a nebulae powered by enough energetic young pulsars. It shows on the map an extended source around a point source. This source is the largest and brightest of the new emission regions of VHE gamma-rays. CO observations reveal an existence of massive star forming region near the source.

The radio map of HESS J1804-216 is shown in the figure below. At 610MHz, this region shows a combination of a point source and an extended structure of the SNR (G8.3-0.0). This SNR lies at a distance of 7 arcmin from the H.E.S.S. position. The flux densities of the counterparts are listed in the table below. Within the H.E.S.S. position uncertainity (i.e. 1 arcmin) we have determined six known field sources and a HII region near the SNR.

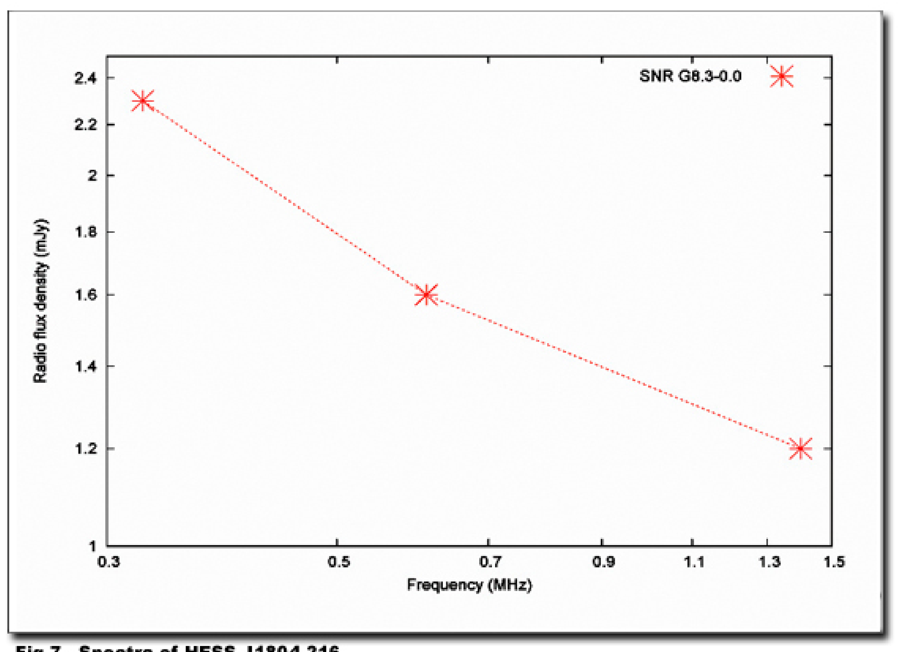

Fig.7 - Spectra of HESS J1804-216

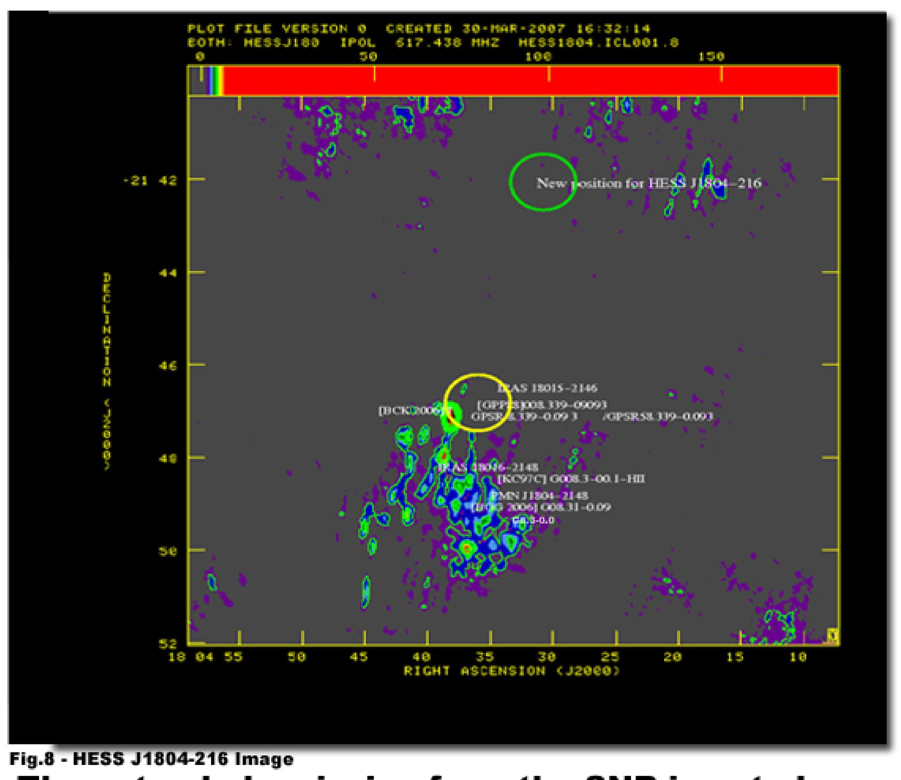

Fig.8 - HESS J1804-216 image

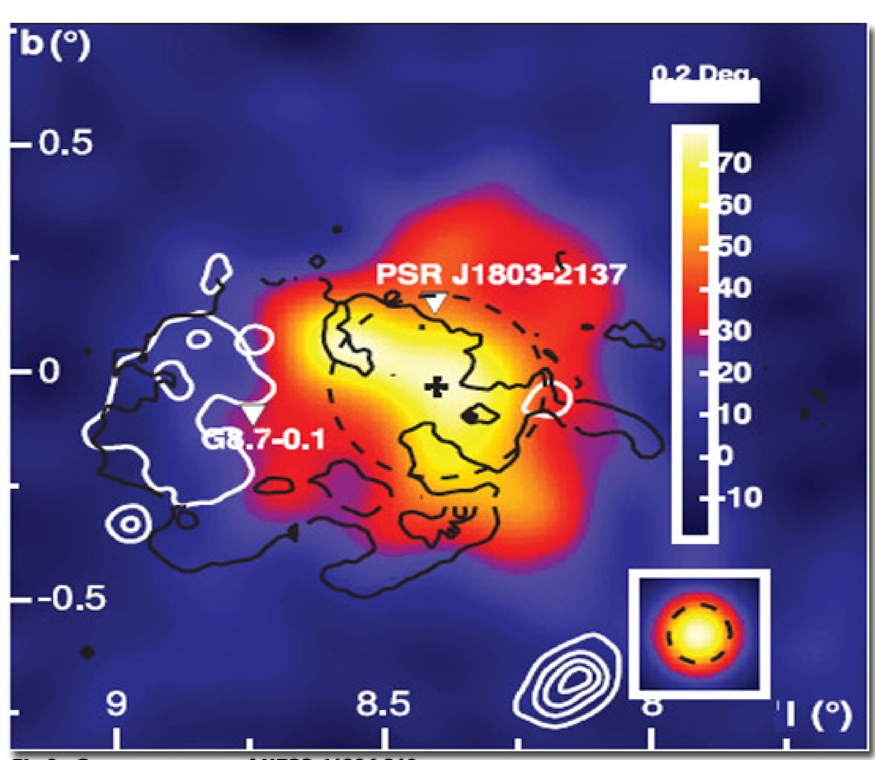

Fig.9 - Gamma-ray map of HESS J1804-216

The extended emission from the SNR is not observed at 5 GHz, suggesting that these emissions are dominant only at lower frequencies. The radio spectra of the SNR is plotted in the figure above. The extended SNR shows power low decay in spectra with the increase in frequency. The spectral index is ~-0.6 for the extended region suggesting a gradual rate of expansion and decay of the remnant. The extended emissions are not seen at 5 GHz.

On comparison with the gamma-ray data from HESS, shown above, we interpret that the radio emissions are dominating from the poor gamma-ray emitting region of the source.

Table

Name	Possible Counterpart	Class	Offset (arcmin)	Distance (kpc)	H.E.S.S. Luminosity (erg/s)	H.E.S.S. Size (arcmin)	S_{610} (mJy)	S_{813} (mJy)
HESS J1640-465	Point / Extended			8.6	16.2	2	15 / 8750 +/- 1.36	7400
	G338.3-0.0	SNR	0					
	3EG J1639-4702	UID	0.18					
	[LBM2006] HESS J1640-465	X	0.85					
	1 XZLJ Ara 16	?	0.92					
	SNR 338.3-00.0	SNR	0.97					
	HESS J1640-465	GAM						

NOTES.– The offset denotes the angular distance of the VHE gamma-ray from the possible counterpart. Distances are taken from Green (2004), Manchester et al. (2005), and references therein. HESS Luminosity gives the implied luminosity between 0.2 and 10 TeV. The possible source classes have been abrreviated according to the following scheme: supernova remnant (SNR), unidentified sources (UID) and gamma-ray (GAM).

Name	Possible Counterpart	Class	Offset (arcmi	Distan (kpc)	H.E.S.S. Luminosity (erg/s)	H.E.S.S. Size (arcmin)	S_{1400} (mJy)	S_{610} (mJy)	S_{325} (mJy)
HESS J1804-216	Point / Extended					22	1200	1580	2350
	G8.7-0.1	SNR	21	6	16.5				
	PSR J1803-2137	PWN	10.8	3.9	7.0				
	[GPD88] 008.339-0.093	RAD	0.01						
	GPSR 8.339-0.093	RAD	0.03						
	GPSR5 8.339-0.093	RAD	0.04						
	[BCK2006] 1	RAD	0.05						
	IRAS 18015-2146	IR	0.93						
	G008.3-00.1	HII	1.77						

NOTES.– The offset denotes the angular distance of the VHE gamma-ray from the possible counterpart. Distances are taken from Green (2004), Manchester et al. (2005), and references therein. HESS Luminosity gives the implied luminosity between 0.2 and 10 TeV. The possible source classes have been abrreviated according to the following scheme: supernova remnant (SNR), pulsar wind nebula (PWN), radiation (RAD) and infrared (IR).

From above table we can see that HESS J1640-465 is an old SNR with the radio emission been genertated at the end of the explosion of the gamma-ray source. The core of the sorce is dominantly emitting at higher energies. On the hand, in the case of HESS J1804-216, radio emissions are generated at the core of the source and the gamma-ray source is considerably big in size.

Discussion

The H.E.S.S. observatory has detected 17 known sources very high energy gamma-rays in our inner part of the Galaxy. The increased number this class of sources has allowed us to carry of low frequency radio survey and explore their multi-wavelength characteristics. The multi-wavelength observations and archival searches has led to understand the nearby regions of these sources and the processes at work in these astrophysical particle accelerators. From our observations, we conclude that SNRs, HII regions and compact objects are closely associated in the evolution sequence of a star. We have also found out that the second class of sources emitting at such high energies are QSOs (as described in our poster 2). Our observations were useful to map the extended regions around these sources and find information about their morphology and exact position. The spectral information suggest that these are non thermal sources emitting synchrotron radiation.

Reference

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-Aharonian, A.G., Bazorbachi, A.R., et al. (2006), ApJ, 636 ,777
-D. Horsl et al., Journal of Physics, 2007, 135-138
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-http://www.mrao.cam.ac.uk/surveys/snrs/

Images

-http://www.mso.anu.edu.au/~plah/Home_Page_Stuff/GMRT_images/large/combined_dishes.jpg
-http://space.mit.edu/EPO/MULTILING/neutro_supernova.gif
-http://lpnp90.in2p3.fr/~hess/IN2P3/hess/images/hess.gif
-http://www.mpi-hd.mpg.de/hfm/HESS/public/som/Som_9_06_p01.jpg
-http://www.mpi-hd.mpg.de/hfm/HESS/public/som/Som_9_06_p11.jpg