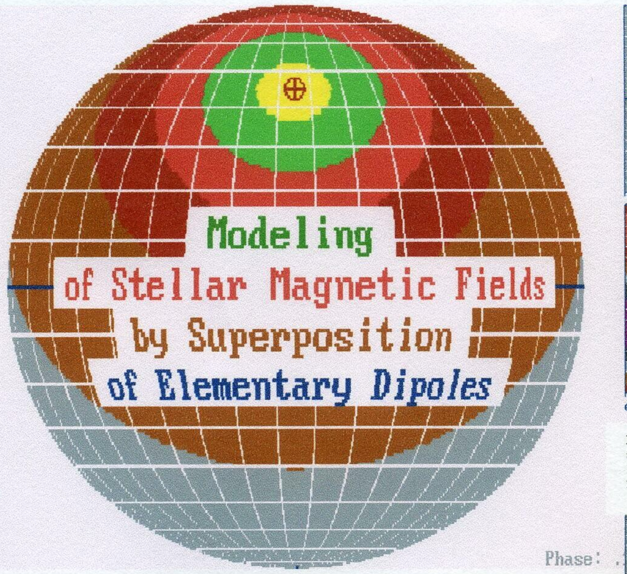
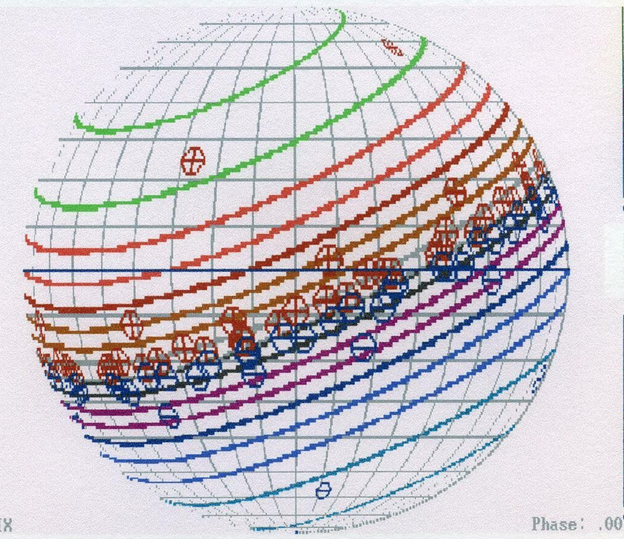


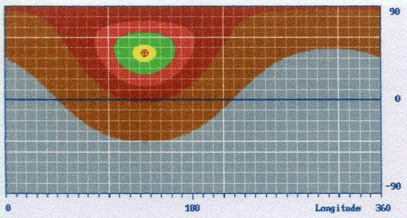
E. Gerth and Yu. V. Glagolevskij

Stellar magnetic fields can only be observed from the surface of the star in integral light, which includes a variety of convolution processes. The deconvolution, however, proves to be an ill-posed inversion for lack of information. Therefore, the straightforward calculation of models and its fitting to the observation becomes important.

We relate to a model of a star, in whose interior the magnetic field is generated by *sources* and *whirls*. In the case of a stable star with a stationary field one has to account only for the magnetic sources, which act analogously to electric charges as *virtual magnetic charges*. Since magnetic monopoles do not exist in reality, only magnetic dipoles are physically relevant. The *magnetic moment* of such a dipole is a vector, being surrounded by a characteristic magnetic vector field. The fields of numerous *elementary* dipoles superpose linearly to multipoles and "super-multipoles" – as the molecular dipoles in ferromagnetic bodies.
This is demonstrated, e.g., by two magnetic dipoles at the same position, the fields of which build again a dipole field with the vectorial addition of the magnetic moments. The elementary magnetic dipoles may be arranged arbitrarily within the stellar body by position and by direction. The combination of elementary dipoles enables one to model different magnetic bodies: rod, cubic, cylinder, ellipsoid etc. Especially interesting is the field of an area of a circle, set with elementary dipoles and forming a "magnetic sheet". The same magnetic field is produced by a circularly streaming electric current as a whirl, such as we can assume circling in the star both in cases of a stellar dynamo and of a frozen-in relict magnetism.

The magnetic field is defined by its coordinates in the interior of the star as well as in the whole surrounding space and can also be determined on any area you like. The most important area is the surface of a sphere - the face of a star, representing the cartographic map with all its topographic features concerning the magnetic field and the element distribution in the star's atmosphere, which will be integrated over the visible disk, convoluted by rotation, and transformed into phase curves of the integral magnetic field.

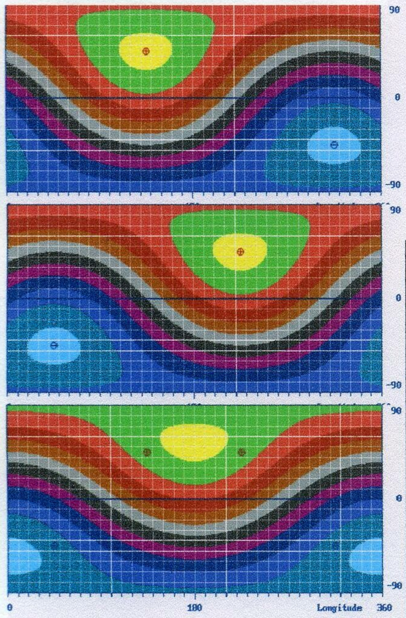




Mercator-map of a positively charged magnetic monopole.
The monopole is determined by 4 parameters:

1. Charge	$Q=1$	(relative units)
2. Radius	$r=0.5$	(fraction of the radius)
3. Longitude	$\varphi=135°$	
4. Latitude	$\delta=45°$	

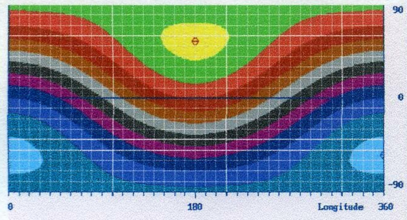
Right: Coordinate transformation into a sphere



Superposition of 2 central magnetic dipoles:

1.	$Q=+1$	$r=0.001$	$\varphi=135°$	$\delta=+45°$
	$Q=-1$	$r=0.001$	$\varphi=315°$	$\delta=-45°$
2.	$Q=-1$	$r=0.001$	$\varphi=45°$	$\delta=-45°$
	$Q=+1$	$r=0.001$	$\varphi=225°$	$\delta=+45°$

3. The magnetic fields of both dipoles superpose by vectorial addition of the magnetic moments to a resultant moment with a dipole field (below)

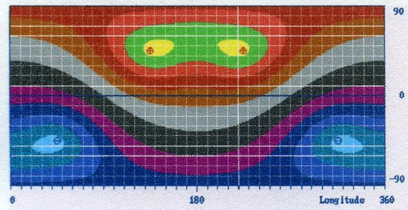


Dipole field calculated by the 8 dipole parameters:

$Q=+1$	$r=0.001$	$\varphi=180°$	$\delta=+55°$
$Q=-1$	$r=0.001$	$\varphi=0°$	$\delta=-55°$

The dipole represents an elementary field magnitude. But only central dipoles with infinitesimal distance between the oppositely charged point-like sources superpose to the normal dipole structure of the field.

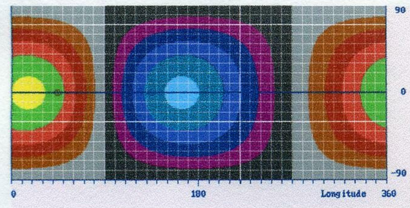
Below: The distance of the four sources is enlarged to $r=0.5$. The sites of the magnetic poles on the surface deviate from the coordinates φ and δ.

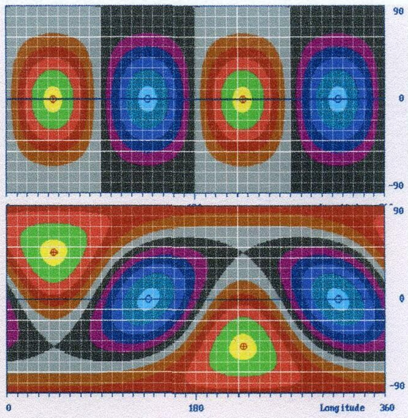


The magnetic charges can be arranged anywhere in the interior of the star. Then the magnetic dipole is shifted away from the center – "decentered". Multipoles consist of decentered elementary dipoles in all arrangements.

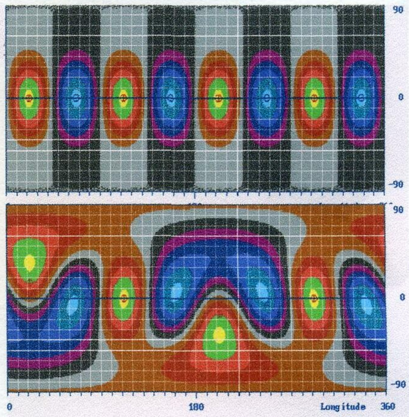
Below: Decentered dipole in the equatorial plane

$Q=+1$	$r=0.1$	$\varphi=45°$	$\delta=0°$
$Q=-1$	$r=0.1$	$\varphi=135°$	$\delta=0°$





Magnetic quadrupoles as arrangements of two decentered dipoles with antiparallel magnetic moments perpendicularly to the radius vector:
1. Dipoles in the equatorial plane
2. Dipoles in a plane tilted to the equatorial plane by 45°

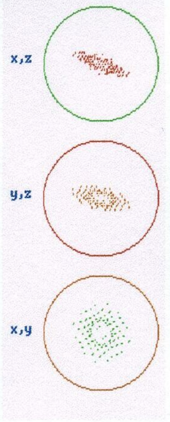


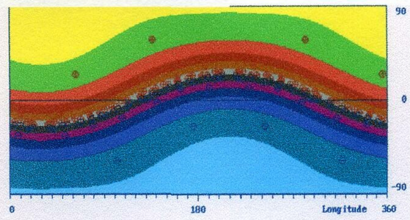
Magnetic octupoles as arrangements of four decentered magnetic dipoles around the center in a plane. The magnetic moments of every two dipoles are arranged antiparallelly and perpendicularly to each other.
1. All dipoles laying in the equatorial plane
2. Plane of the dipoles constituting the octupole tilted by 15°

"Super-multipole" consisting of 80 dipoles as a double layer of positive and negative monopoles in on circle area.
Construction of the "super-multipole":
1. All dipoles have equally two oppositely charged field sources.
2. Each dipole has a distance of the point-like charges of 0.01 R.
3. The dipoles are set within the circle $r=0.5$ R in a grating of 10*10, yielding thus 80 dipoles (160 points).
4. The circle in the x,y-plane is tilted with its z-axis to the equator by 30°.
5. The tilting of the sheet is performed by a coordinate-transformation of each point in polar-coordinates.

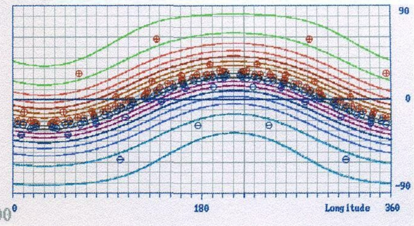
At the right side the charges are represented as dots in the cross sections with the coordinates φ and δ in the three orthogonal planes x,y y,z and x,z. The grating seems to be distorted pillow-like and empty in the middle. This is because of the shifting of the charge points along circle paths.

Below: Map of the surface field distribution. The zero-line divides the positive and the negative charges, most of them lying nearby it. Only the four dots in the middle of the x,y-plane deviate.





Mercator-map of the circular magnetic sheet approximated by 80 dipoles, represented with cartographic coordinates and iso-magnetic lines
Left: Spherical coordinate-transformation of the map to a globe.



Poster representation at IAU Symposium 210 in Uppsala/Sweden, 17-21 June 2002