# Starball of the Future

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Abstract.
For many, many years starball projectors have created unique and inspirational experiences for audiences to explore the wonder of the night sky. Now, digital technologies are being added to opto-mechanical instruments to provide the additional functionality that the starball is unable to deliver. Currently these competing technologies coexist in the same marketplace and often in the same theater. At what point in the future will the new replace the old?

So what does the future hold? What is the Starball of the Future?

*"The Planetarium-as-theater is not drama merely for the effect of drama; not entertainment for the sake of entertainment; not even science for the sake of science, but it is an elucidation of the scientific endeavours of man in his quest for an understanding of the worlds of space and time in a planetarium setting which is interesting, inspiring, and educational"*
*Hagar, 1969*

## Introduction

The opto-mechanical star projector or 'starball' of today was developed from the need to accurately simulate and describe the night sky to a variety of audiences; from students and military personnel to the general public. Installed and in use in approximately 85% of the 3,600 or so planetariums around the world, the starball is a unique and revered instrument.

In all forms, the modern starball consists of a light source or sources illuminating an array of optical masks or fiber optic elements through which the stars of the night sky are represented in high detail and accuracy. These light points are combined if necessary with optical elements to focus the resulting simulated starlight onto the hemispherical projection screen under which the audience sit.

Simulating the Earth's daily rotation, the capability of the starball extends from simulation of Earth's latitude and equinox precession through to pinpoint accurate projections of bright astronomical objects. Modern versions of the projector employ supplementary, smaller units to display individual stars such as Vega and Canopus, and to bring additional astronomical 'objects' (including nebulae, galaxies, planets, moons and comets) onto the dome screen – fully representing the night sky.

Although the opto-mechanical star projector has significantly developed since the 1920's with the pace of technology and manufacturing evolution, the commonality across old and new models continues to see the whole contraption typically built into a spherical enclosure which sits proudly in the center of the theater, or on occasions rising majestically into the theater on a mechanical lift when called for.

Motion of the stars across the sky is achieved simply by rotating the ball on both axis around its center point. A comprehensive control console is provided for an operator to manually control the entire presentation.

## Brief history of the opto-mechanical starball

The first starball projector in the current conventional form was created by Dr. Walter Bauersfeld at the Carl Zeiss Optical company in 1919, and was quickly followed by integration of the projector into the first public planetarium theater in 1925 at the Deutsche Museum, Munich (following several demonstrations of the new technology in Germany between 1923 and 1925).

Between 1930 and 1949, twenty-five of the early Zeiss starball models were produced, with six erected in the United States and the rest installed around Europe. Europe and Japan primarily used these environments for celestial navigation training during the war, whereas the USA continued public demonstrations. Armand Spitz (affectionately referred to as the 'Henry Ford' of planetariums) then began to devise new models with an overarching aim to make these pieces of machinery more widely available (particularly in the USA), and to diminish the cost-prohibitive stigma that had become attached to the starball projector. By the mid-fifties, over 150 Spitz planetariums were installed in schools, colleges and museums.

In the early 1950's, the increasing public interest in the Space Race rapidly spurred on the development of planetariums, with a number of unique starball models produced for facilities including the California Academy of Sciences (The Academy) and the Boston Museum of Sciences (The Korkosz). The United States Government launched a program to install over 1,200 planetariums in High Schools across the country during the 1950's and 60's which created further demand for planetarium projectors and thus opened up opportunities for new market entrants.

The 1960's established new players including Japanese firms GOTO Inc. and Konica Minolta Planetarium Co. Ltd, and further strengthened Spitz's position as a supplier of planetarium technology to the 'classroom'. As of June 1968, there were at least eight companies manufacturing planetariums on a regular basis (Hagar, 1969).

## The starball of today and its evolution

Various vendors including GOTO, Konica Minolta, Megastar, RSA Cosmos, Sphaera, Spitz and Zeiss continue to manufacture opto-mechanical projection technologies, maintain extensive installed bases across the world, and provide teaching tools in the field of astronomy education.

Today, these manufacturers offer a range of solutions, each with their own inherent characteristics, and with unit prices spanning from US$200 for entry-level, home versions of the projector through to multi-million dollar top of the range professional models.

Due to the design of the starball, its fundamental limitation is that it is Earthbound. That is, its whole premise is to accurately represent the sky from a position on Earth. It is now possible to gain a far greater appreciation of the cosmos by removing the tether to Earth and taking off to travel out towards the far flung reaches of the universe. Increasingly, the starball is supplemented by a digital projection system, popularly referenced as a 'hybrid system', to provide these features. Modern digital projection systems developed specifically for planetariums, commonly referred to as Fulldome systems, allow just that.

## Digital vs. opto-mechanical

Digital Fulldome systems encompass highly accurate databases of the known universe and via a number of techniques and interfaces allow the presenter to not only represent the night sky when viewed from Earth, but also to travel at any speed and distance to any location of the known universe.

However these Fulldome systems typically lack the unique optical characteristics of the starball, those being extremely high star-point resolution and exceptionally dark black levels. The nature of most projection systems is that the imaging system uses a fixed light source and a light modulator consisting of a matrix of discrete picture elements (pixels) whereby each pixel can be controlled to let a proportional amount of coloured light through a lens and onto the screen. The construction is referred to as a 'light-valve'. Due to the nature of the majority of projection systems these light valves leak a small amount of light even when a pixel (or pixels) is switched off to black. Therefore the black level of these Fulldome systems is typically gray. Depending upon the overall brightness capability of the Fulldome system, the gray level is a function of the brightness and the native contrast of the projectors utilized.

Consequently when a Fulldome system is used alongside a starball in some kind of combination or hybrid mode, the gray level from the Fulldome system contaminates the exceptionally dark black level of the starball and literally washes out one of the key benefits of a starball. Workarounds are employed using shutters, various methods of lamps modulation or irises to further dim the projection system light closer towards black when used alongside the starball but they are just that; workarounds that each have some form of limitation.

## Trends

A small number of digital projection systems have entered the market recently that are specifically developed to produce exceptionally dark black levels while concurrently projecting bright white light points. These ultra-high contrast projectors have been developed to complement the opto-mechanical starball or to even work alone to project their own starfield. As of today two products exist in the market; the Velvet projector produced by Zeiss AG and Zorro® produced by Rockwell Collins, Inc.

Both products are quite similar in construction, utilizing the light valve approach but adding further light modulation to achieve extremely high instantaneous contrast levels of around 1,000,000:1 or higher and consequently extremely dark black levels rivalling that of a starball. Uniquely these products can project the dark black levels whilst simultaneously displaying their own bright starfield or any other content. Because of this they truly qualify to be starball compatible and will happily run alongside a starball unnoticed, without causing any light pollution.

By combining these projectors into an array, higher and higher resolutions can be achieved simply by adding projection devices. At this moment in time it may be impractical to achieve the extremely high star resolution of the very best starballs by this method, but at some point the resolution and image fidelity of these exceptionally high contrast Fulldome systems will be sufficient, especially for audiences who do not have the benefit of side by side comparisons.

## The Future

As digital projectors and the associated computing technology and software continues to improve, one can imagine a future, perhaps some time away, where the opto-mechanical starball of tomorrow is fully integrated inside the Fulldome system obviating the need for synchronization, hybridization or any other such means to combine two previously competing technologies.

Like the vinyl record that migrated away from its analog roots in the form of CD and now into fully integrated solid state digital memory devices, the Starball of the Future will digitally evolve into a form that would not be recognizable today.

The debate about how far into the future we must wait be will be a long and fascinating one (much like the vinyl versus digital debate) and bring the best minds of the industry to task to justify, quantify and demonstrate their position. The benefit of all of this will be for the user and the audiences. Prices for the optical only instruments will tumble (as they already are) and features of the all digital systems will expand to better suit the enormous variety of content and imagery that these high-fidelity devices will be capable of displaying in life-like clarity.

This will continue to open up the opportunities for the modern planetarium as a unique venue free from Earth-centric projection to visualize a range of sciences in a unique visual experience, truly immersive, increasingly realistic, engaging and compelling.

The future is bright. The future is black.

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## About the Author: Martin Howe

Martin Howe is Chief Executive of Global Immersion. With over 25 years experience in the field of immersive theatre, display technologies and integrated computing and audio-visual experiences. His background includes management and direction at a senior level, with particular focus on global marketing, project engineering, complex system integration and product development.

## About Global Immersion

Global Immersion is an award-winning organization, dedicated to the unique and innovative medium of immersive theater and specializing in the design and integration of world-class planetarium, giant screen, 3D and 4D environments.

With over thirteen years experience in the world of fulldome displays and scientific data visualization, Global Immersion combines a wide range of proven technologies to create enthralling and exciting immersive theater. As a full-service team, they pull together consultancy, design, technology, engineering, system integration, content and creativity – for world-class experiences that are built for the future.

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