The Ethos Suggested by Landscape Markers: the Tiled Dome

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Domes communicate with the surrounding context, they irradiate qualities in the landscape that should be studied regardless of the response of the individual viewer. We tackle the issue here by approaching the phenomenon from a scientific point of view and by analysing the causative reasons of the subjective experience on the basis of documented results. Having determined an incident and reflected solar radiation equation for oblique surfaces which can be applied to a model of a spherical tiled dome, the calculated powers were diagrammed on a vertical section plane. Despite the limitations due to simplification, the results provide indications which can shape the logic of a design plan capable of accounting for the existential sensitivity of landscape markers.

Keywords: *glazed tiles, the existential sensitivity, landscape markers*.

1. Introduction

Domes represent focal points towards which the viewer directs his gaze. Modern man, with his positive attitude, is inclined to accept, naturally, phenomena which occur regularly, he rarely wonders about them and tends to just experience their effects (R. Arnheim, 1962). The intensity of the "affective" response to the phenomenon will vary according to the viewer but the phenomenon as such should be investigated in isolation: it is not just a question of empirical configuration but of how it appears at a certain time under certain conditions. The brilliance of the tiles, the atmospheric conditions, the time of day, the latitude and the trajectory of the light rays contribute to the mutability of the context and thus the domes define the attributes of a significant space. (A. Rossi et al, 1996). Designers are accustomed to tackling the material properties but they rarely plan the effects of the attributes: these qualities are less evident but definitively causative of the existential qualities (ethos) of the environments. Buildings and town squares, just like other natural or "anthropized" (man- modified) environments can be inviting or off-putting, welcoming or cold, cheerful or depressing, They generate "atmospheres" (habitats) which affect the viewers who may be more or less aware of the phenomenon. (H. Werner, 1966). Those who deal with intermodal qualities should consider the issue and tackle its objective components.

2. The dome roofed with glazed tiles

The "dialogue" between landscape markers and viewers is animated by domes roofed with tiles glazed in yellow and green, yellow and brown, yellow and azure and arranged in geometrical patterns (G. Donadone, 1974, p. 11). The tiles are fired twice, their thickness is of a few millimeters, their length, 27/30 cm and their width 16/20 cm. At the top they are shaped so that they can be nailed and arranged in a herringbone pattern and they provide a slippery surface where water flows easily away. The glazed tiles are resistant to the sun and rain, which are very important characteristics at southern latitudes where rain is abundant and the sun reflected by the sea is extremely hot (A. Rossi, 2006).

Aragonese documents prove that Naples imported from Valencia skilled craftsmen as well as "rajoletes pintados" (rajo ray, lightning) i.e. tiles which were locally

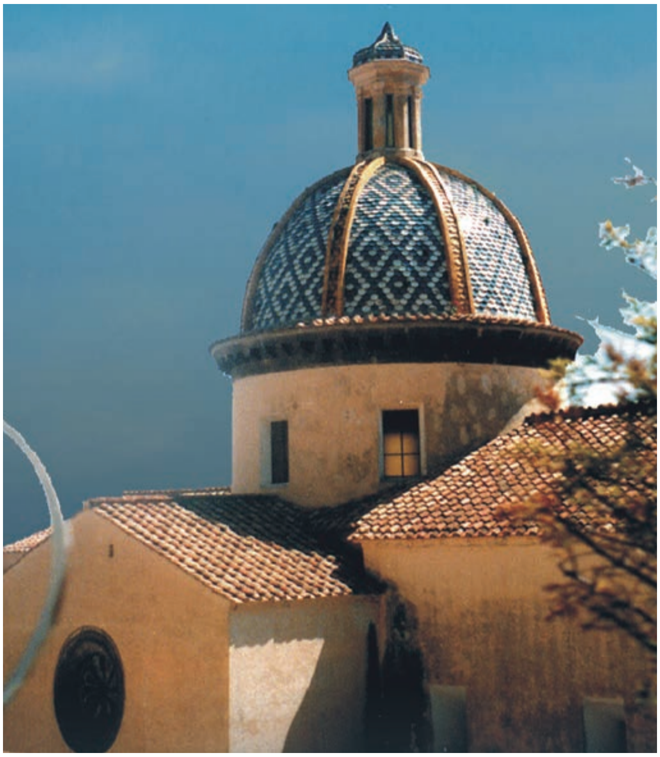

Fig. 1. Multicolored glazed tiles a) domes on the Amalfi coast.

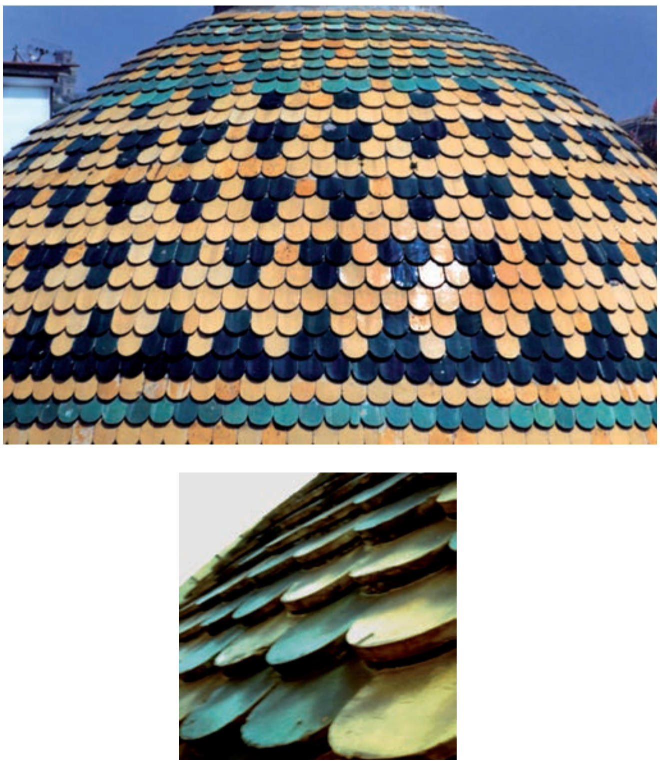

Fig. 2 - Details of the Santa Maria dome in the port neighbourhood of Naples.

called “rigiole” or “rizole” and which , in fact, revitalized the local clay modeling craft thanks to new techniques. The Roman arched tiles and the “square trapeze” tiles from the middle east (from *agiur,* bricks) can be considered the “ancestors” of the glazed tiles. Between the 17^{th} and the 18^{th} centuries, in the Kingdom of the Two Sicilies, tiles were used for internal and external surfaces (G. Donatone, 2001). Nailed to proto-baroque surfaces and fixed with a mixture of lapillistone and mortar, they stand out for their colors which resemble those of the polychrome marbles that were widely employed at the time. The terracotta glazed with brilliant color pigments lowers the emissivity of the material and increases the amount of energy it can irradiate compared to a black body at the same temperature (emissivity $\varepsilon = 1$). Actually, the emittance in any given point of the glazed tile, measured in a certain direction, varies according to the heat on the lamina and to other characteristics as well which include the inclination of the glazed surface with respect to the direction of the solar rays. Therefore, there are several parameters to consider in order to assess the impact of the mechanisms that govern the effects of light in different points and the relationship between these and the energy emitted by the other bodies at linear distance. Electromagnetic emissions of different wavelengths travel through space and as they go through it they generate complex phenomena compared to the initial geometries which are difficult to describe visibly and mathematically. Even if one wanted to study only the trajectories of the incident and reflected rays, ignoring the diffuse and refracted ones, reality deteriorates the initial phenomenon, making it impossible to represent or calculate the quantities that generate the perceived effects. When the source of primary light is natural like the sun the complexity of the design that is generated in the atmosphere of the illuminated bodies is an immediately dynamic phenomenon. Compared to the imponderable variability of the parameters that determine the result in a certain instant, the geometrical characteristics of the single bodies, the materials, the configuration of the landscape where the domes are set, can be considered constant. The latter can be used to understand and control the variables described by the laws of science to identify the causes of the synchronisms that precede the conscious perception of the viewer.

3. The mathematical model

The sun transfers to the earth's surface a more or less constant amount of energy per unit of time. Measured at the external threshold of the atmosphere per unit of surface at the average earth-sun distance, it provides data which is necessary to quantify the flux of incident solar energy (I) on the surface of a body which we initially consider plane. A standard equation commonly found in literature allows one to define the expression necessary to quantify the distribution of daylight that reaches the earth considering the height of the sun on the horizon (θ) and the transmissibility coefficients of the atmosphere (τ_w e τ_a), allowing the calculation for the attenuation of radiation due to water vapor, aerosols and dusts :

$$I = l_{\circ}\, \tau_w\, \tau_{a,}\, sen\theta \qquad (1)$$

Where:

(l°) is the solar constant which is equal to 1360 watt/m;
θ the height of the sun on the horizon;
τ_w the attenuation coefficient for water vapor and which is equal to $0,896 - 0,0636 \log W/sen\ sen\theta$ with $W=200q$ *(q=umidità specifica)* (A. Slingo, H. Schrecker, 1982);
τ_a the coefficient which is equal to $\exp[-\mu\ (1/\cos\theta]$ i where µ represents the torbidity coefficient which ranges from 0.07 for very clean air and 0.6 for polluted air which accounts for aerosols (M.H. Unsworth, J. Monteith 1972).

If one considers that the clouds absorb and reflect part of the power, the incident energy flux becomes (M. Iqbal, 1983)

$$I' = I(l\text{-}c) = I(1\text{-}0.4\,Ch)(1\text{-}0{,}7\,Cm)(1\text{-}0.7Cl) \qquad (2)$$

Where *Ch, Cm*, and *Cl* represent the values obtained considering high, medium and low clouds.

As it is necessary to calculate the radiation on oblique surfaces, because such is the broken line that subtends the discretized curve, one needs to bear in mind certain geometrical considerations concerning the angle of incidence (Φ) identified in each point

$$\cos\Phi = \cos\beta\ \cos Z + sen\beta\ senZ\ \cos(\Omega\text{-}\Omega')$$

Where:
β = the angle between the surface and the horizontal plane;
Z = zenith angle;
Ω=azimuth angle;
O' Azimuth of the oblique surface.

As known, the azimuth is the angle formed by the incident ray with the orthogonal surface at the point while the azimuth angle depends on the dihedral angle which is formed with respect to the system of equatorial coordinates when one considers the meridian arch comprised between the equator and the parallel intersecting the considered surface.

The equation is then:

$$I' = I\ \cos\Phi(1\text{-}c)$$

If the plane is horizontal, as initially assumed, β =0, then $\cos\Phi = sen\,\theta$.

As might be easily inferred, the reflected radiation depends also on the characteristics of the body: the albedo (from *album*, white) measures the reflectance coefficient which, due to the specular imperfection, determines phenomena that visibly alter the specular reflection generating optical effects (M. Iqbal, 1984).

Assuming it is possible to avoid a "Lambert" effect, the different color of the tiles, and therefore the different albedo value (α) varies in a quantifiable way:

$$R = \alpha\ I'$$

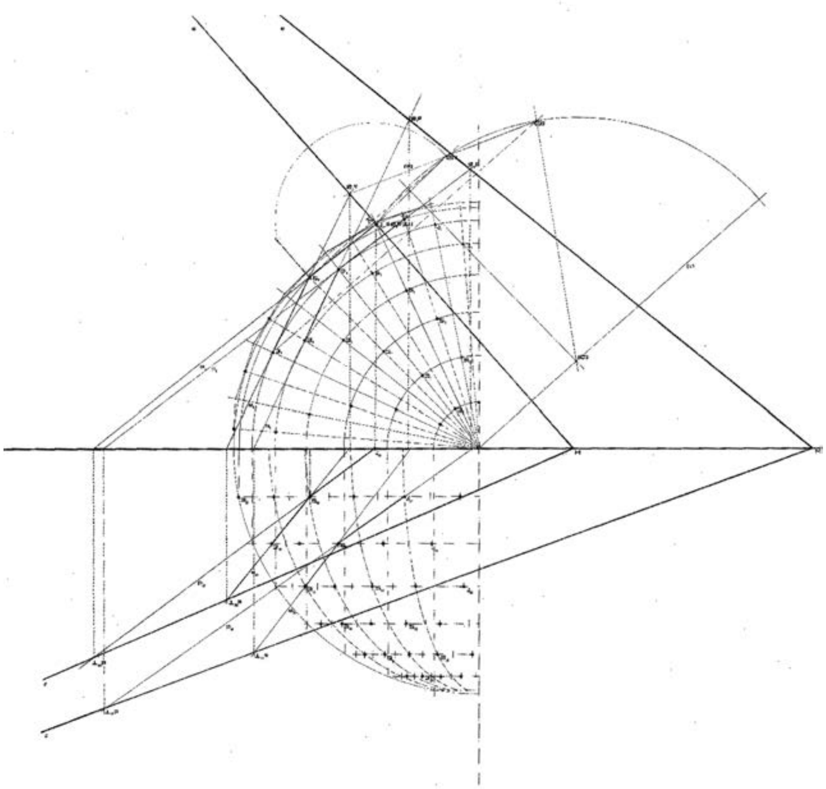

Fig. 3. Orthogonal projections. Demonstration of the coplanarity fixed on the same level.

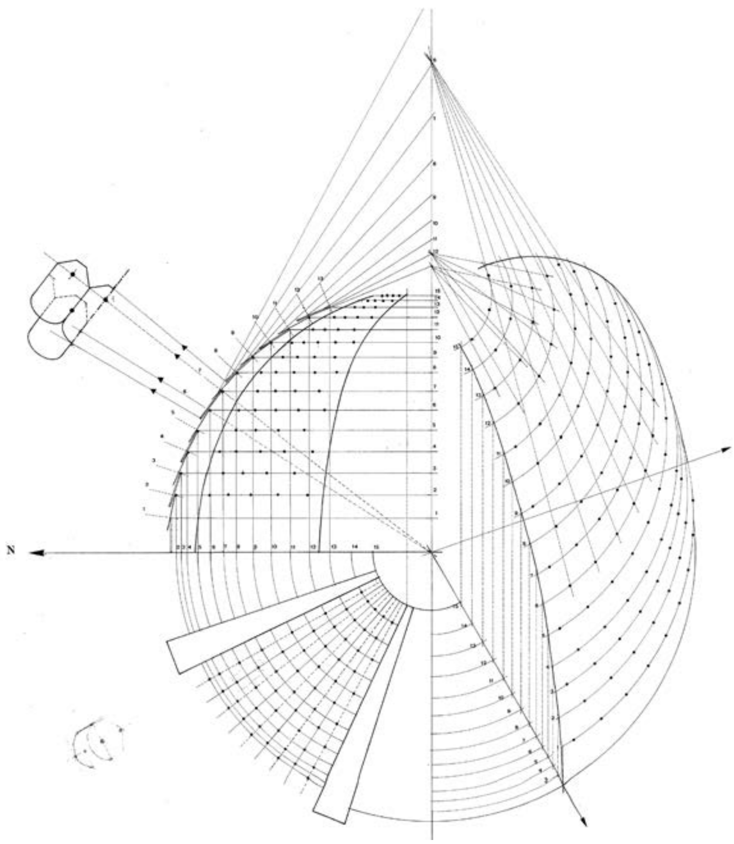

Fig. 4. Orthogonal and parallel projections of the geometrical scheme. The dots represent the nail holes necessary to fix the glazed tiles on the dome shell.

4. The geometrical model

In order to calculate the equations, a geometrical scheme is necessary to derive the volume, even if theoretical, of a glazed tile dome (A. Rossi et al 1996). A half sphere shell, divided by the geographical north, in four parts is considered. In order to discretize the polychrome roofing, a vertical section, intersecting the center of the sphere, of the volume-shell is drawn. The radii, multiples of 10° were drawn: nine points were identified on the profile and the same number of planes parallel to the diameter. Considering the incident rays orthonormal to these points, the incident and reflected powers have been calculated for an ideal tile abstracted as a lamina (due to its small width compared to the area) with a 1 square meter surface. As to the reflecting power of the yellow and green glazed material, emissivity expressed as a percentage ranging between 0 and 1 was considered without the real deformations that do not allow specular and coplanar reflection. Referring to the mean values reported in the most widely consulted texts and assuming the albedo to be 0.7 for the yellow glazed and 0.3 for the green glazed surfaces (9) values for the sample days were obtained: the solstices and the equinoxes calculated at the latitude of Naples at 7 am and 1 pm (the data was collected at the military aeronautical station in Capodichino) The powers were described with reference to the vertical profile of the Monge section of a theoretical volume. The diagrams expressed in the same measurement unit w/mq in sunny, partially cloudy and cloudy conditions were concentric. A dot highlights under the same conditions the reflected values according to the color (yellow or green). Due to the chosen scale of representation some data concerning cloudy conditions were omitted.

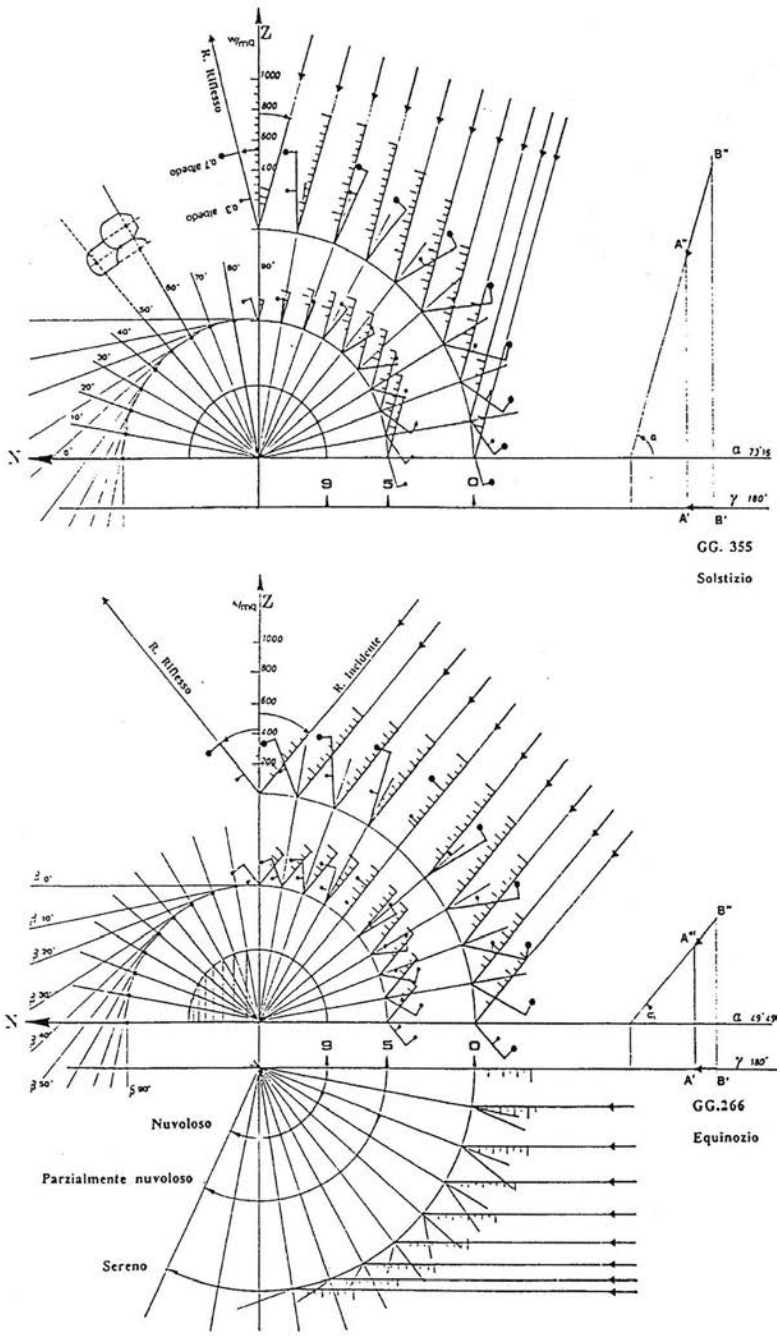

Fig. 5. Diagram of the incident and reflected radiation for surfaces. The balance is obtained for green glazed terracotta tiles (a = 07, internal dot) and yellow glazed terracotta tiles (a = 039 external dot) inclined every 10 degrees with respect to the dome shell and calculated at the latitude of Naples for the spring equinox and the summer solstice at 7 am and 1 pm in sunny (0), partially cloudy (5) and cloudy (9) conditions (data obtained from the meteorology station of Capodichino).

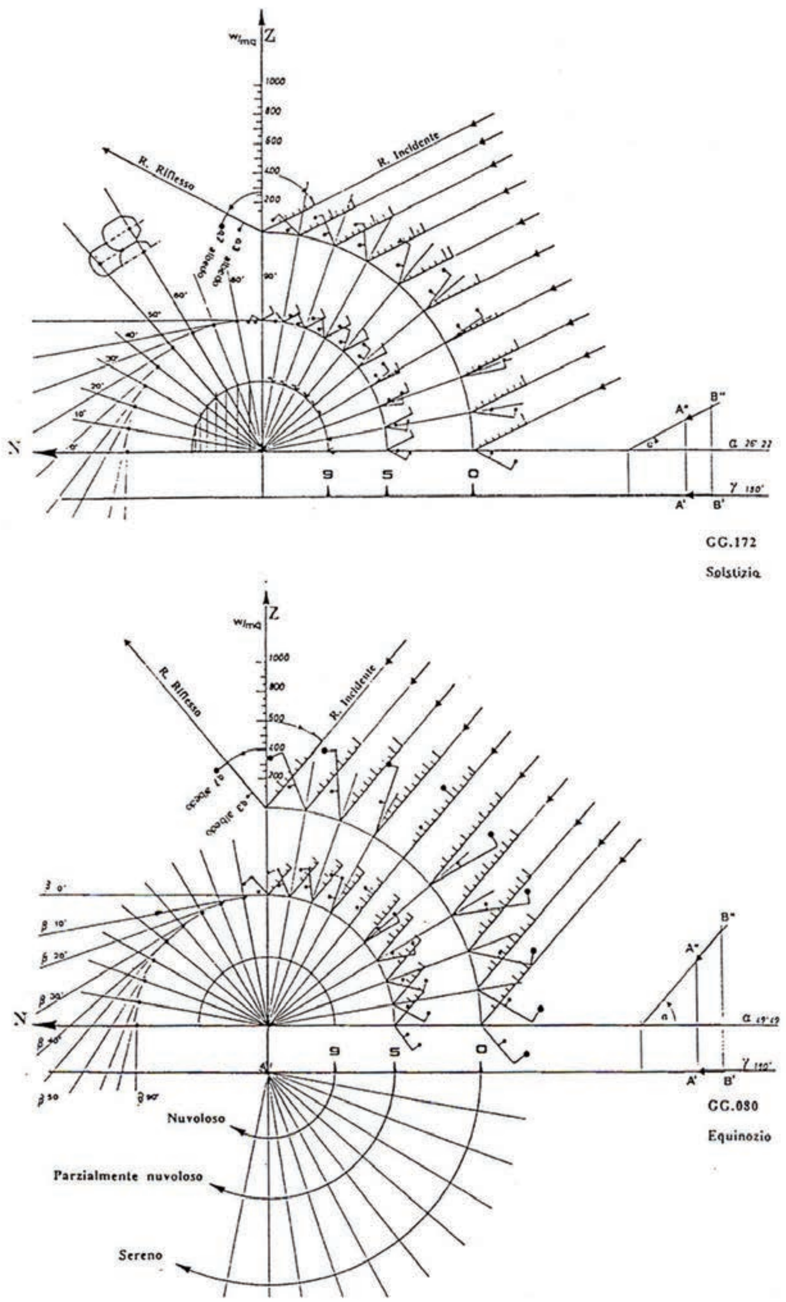

Fig. 6. Diagram of the incident and reflected radiation for surfaces. The balance is obtained for green glazed terracotta tiles (a = 07, internal dot) and yellow glazed terracotta tiles (a = 039 external dot) inclined every 10 degrees with respect to the dome shell and calculated at the latitude of Naples for the spring equinox and the summer solstice at 7 am and 1 pm in sunny (0), partially cloudy (5) and cloudy (9) conditions (data obtained from the meteorology station of Capodichino)

5. A consequence

It is evident that the diagrammed representation was based on ancient assumptions such as; 1) The rectilinear propagation of light; 2) the coplanarity of the incident and reflected rays with respect to the orthonormal; 3) the specular equality of angles. These assumptions enabled Euclid to lay down the bases of a theory of vision and in parallel a geometrical theory (A. Sgrosso, 1979). Classical optics was thus a study explaining the sensations that the human eye perceives through transparent media, while the development of Euclid's geometry enabled man to formally satisfy his natural aptitude to use a bi-dimensional map to order knowledge on distinct planes: drawing thus became the privileged domain where issues could be clarified, content communicated and evolutive and creative thought oriented. From this perspective if in the realized diagrams the incident rays are lengthened considering the reflected power according to material and color and therefore the chromatic effect of the tile, at the intersection of the points collision phenomena can be represented which change the initial geometry and record phenomena that complicate it and cannot be represented on the section planes also or only by a point. If drawing is to explain, even only schematically, the constitutive mechanism of the structured phenomena it will be necessary to reconstruct at least some of the phases of the causative relationships: experience suggests studying diffusive diagrams for which linear geometry seems to have exhausted its explicative potential while geometrical optics is still a branch of contemporary science that studies important phenomena concerning tonality and the effect of color with reference to the chromatic spectrum. There are programs that simulate luminous effects even in cases of very complex geometry. There has been an evolution from software that could represent raytracing models (which transcribed the phenomenon so that it could be dealt with directly and thus simply) to software which can consider diffuse radiation and the dispersion of the rays that having crossed the medium return and hit the represented surface again. Plane schemes cannot make the causative mechanism of the "weights" visible in such a way as to define the parameters needed to assess the impact of perception. Renderings, photo-realistic as they might be, calculate shadows as they are perceived through conscious images that cannot be assessed in the way they are linked and sequenced.

For those who are used to using environmental monitoring instruments for an adequately integrated relief, the evolution of remote sensing techniques has made it possible to obtain qualitative and quantitative data. In fact reflectometers can measure the brilliance of any surface indicating the value of the luminosity and the reflecting power of the material. However, to date there are no instruments which can account for the multi-direction of the phenomena causative of the complex and dynamic atmospheres of environments prior to or during the design process.

Conclusions and further research

If we advocate the idea of a theoretical model, the control of light – a scientific issue that is of interest in all fields – we can guide understanding the striking contrast with an inadequate technology that tends to encourage passive experience rather than promote interest in the description of phenomena. The lack of practical experience is such that it is difficult to go beyond the relief of material qualities. The evolution of innovative technologies developed through systems of active sensing undoubtedly provides interesting elements to explore both from a theoretical and an operative point of view if one intends to encourage the aesthetic operators and the viewers to understand rather than just perceive phenomena that cannot be directly dealt with because they are due to diffuse radiation, refraction and the dispersion of the light rays which return to the surface after having passed through the medium. In our case, chosen as a sample, it will be important to understand, calculate and describe the role played by the single terracotta lamella in generating the global phenomenon.

References

Arnheim, Rudolf. *Arte e percezione visiva*. Milano: Feltrinelli 1962. ISBN 9788807100239. Tit. Orig. *Art and visual perception A psicology of the creative eye, Berkeley*, 1954.

Donatone G., *La riggiola napoletana. Pavimenti e rivestimenti maiolicati dal Seicento all'Ottocento.* III Edizione. Napoli: Grimaldi e Co, 2001, ISBN: 9788888338095.

Donatone G., *Maiolica napoletana dell'età barocca,* Libreria Scientifica Editrice, Napoli 1974, p.11.

Fechner, Gustav. *Specielles zur Methode richtiger und falscher Fälle.* In: Elemente der Psychophysik, Vol. 1, pp.93-120. Leipzig: Breitkopf und Härtel, 1860. ISSN 1866-4784.

Iqbal M.. *An Introduction to Solar Radiation,* Academic Press, Canada. Academic Press, Orlando, FL1983 Jan 01 OSTI ID: 5596615.

Oke T.R., *Boundary Layer Climates,* II° edizione. Cambridge: Methuen Routledge 1987. ISBN 0203407210.

Rossi A., *Sinergie di uno spazio luce. Le cupole maiolicate.* In: Il disegno di progetto dalle origini al secolo XVIII. p. 478, Roma: Gangemi, 1997. ISBN/ISSN: 8874487665

Rossi A., *Estradossi e policromie: ibridazioni mediterranee.* In: Spazi e culture del mediterraneo. p. 573-585, Roma: Ed. Kappa, 2006. ISBN/ISSN: 8878907219.

Rossi A., Siani A.M. *et al. La cupola maiolicata della chiesa Santa Maria della Sanità a Napoli: radiazione solare incidente e riflessa nella caratterizzazione architettonica e ambientale,* in Boll: Geof: 9 anno 19, n.3-4, pp.29-37 maggio dicembre 1996.

Slingo A., Schrecker H.M., *On the shortwave radiative properties of stratiform water clouds,* in Quarterly Journal of the Royal Meteorological Society, Vol. 108, Issue 456, pp. 407-426, April 1982.

Sgrosso A., Lo spazio rappresentativo dell'architettura, Napoli: Massimo Ed. 1979.

Unsworth, M.H. - Monteith J.L., *Aerosol and solar radiation in Brita,* in *Quarterly Journal of the Royal Meteorological Society*. Volume 98, Issue 418, pp.778-797, October 1972.

Werner H., *Intermodale Qualitäten (Synästhesien)*. In: Metzger, Wolfgang: Handbuch der Psychologie. Bd. I,1. Göttingen 1966, S. 278-303.

Weber E.H., Ross H.E., Murray D. J., *E.H. Weber on the Tactile Senses*. II Edizione. Erilbaum (UK): Taylor & Francis, 1996. ISBN 0863774210.