Title: Background independance and the left-right distinction

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Abstract:

Background independence and the left-right distinction

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Gottfried Leibniz

The great foundation of mathematics is the principle of contradiction, or identity, that is, a proposition cannot be true and false at the same time. This single principle is sufficient to demonstrate every part of arithmetic and geometry, that is, all mathematical principles.

Gottfried Leibniz

The principle of sufficient reason

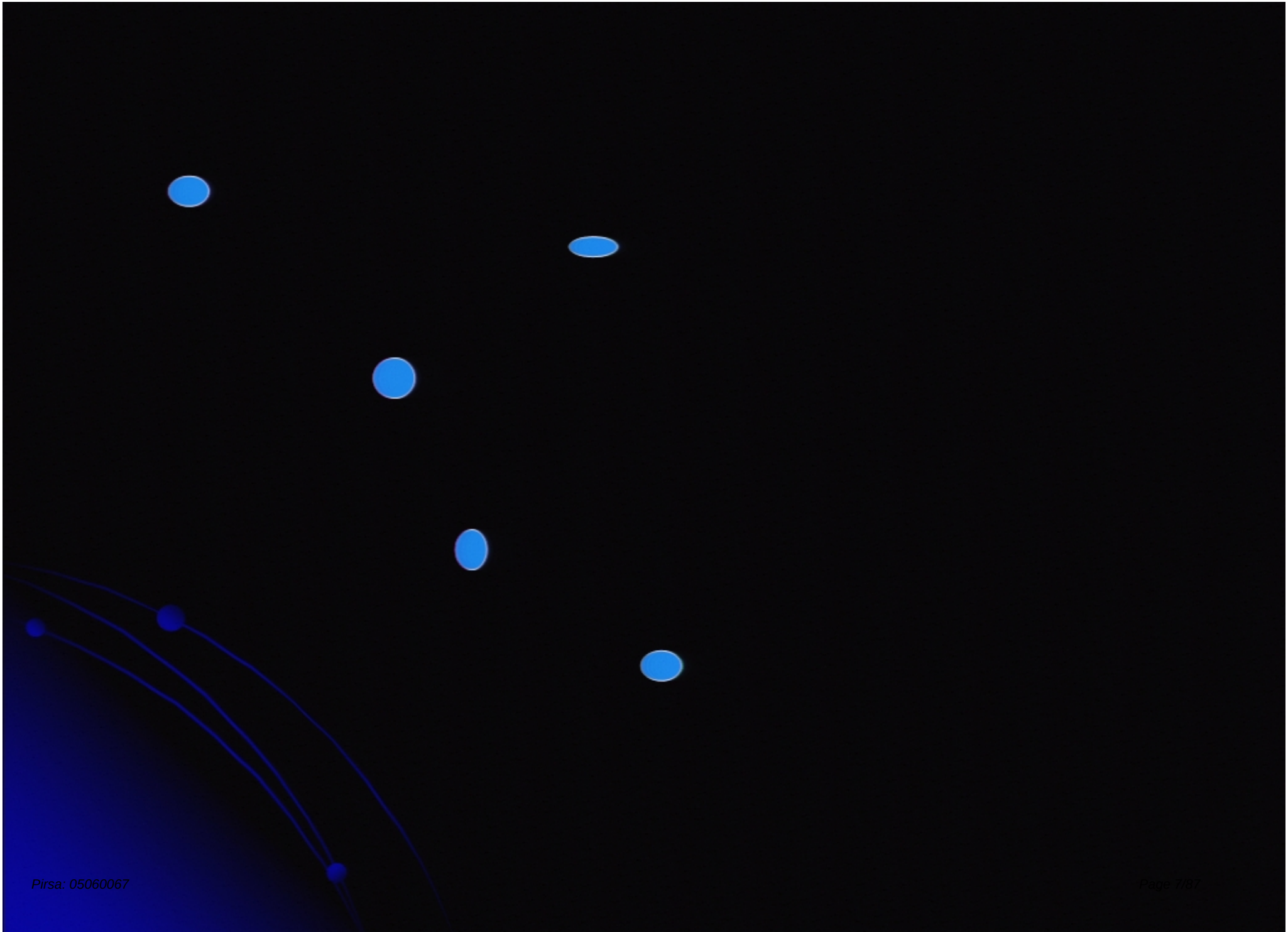
But in order to proceed from mathematics to natural philosophy, another principle is requisite: I mean, the principle of sufficient reason, viz., that nothing happens without a reason why it should be so, rather than otherwise.

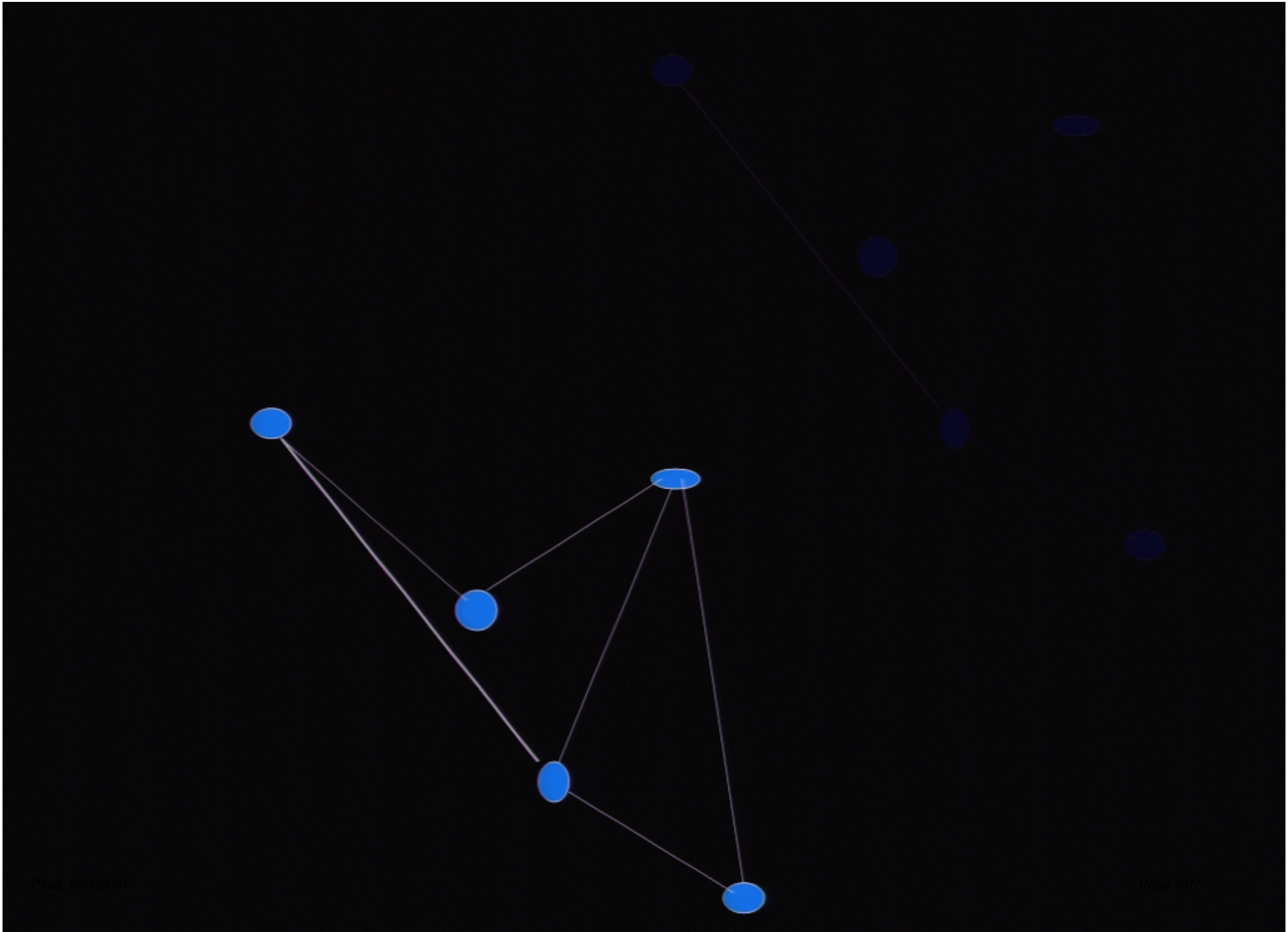
‘Tis very true, that nothing is, without a sufficient reason why it is, and why it is thus rather than otherwise. And therefore, where there is no cause, there can be no effect. But this sufficient reason is oft-time no other, than the mere will of God.

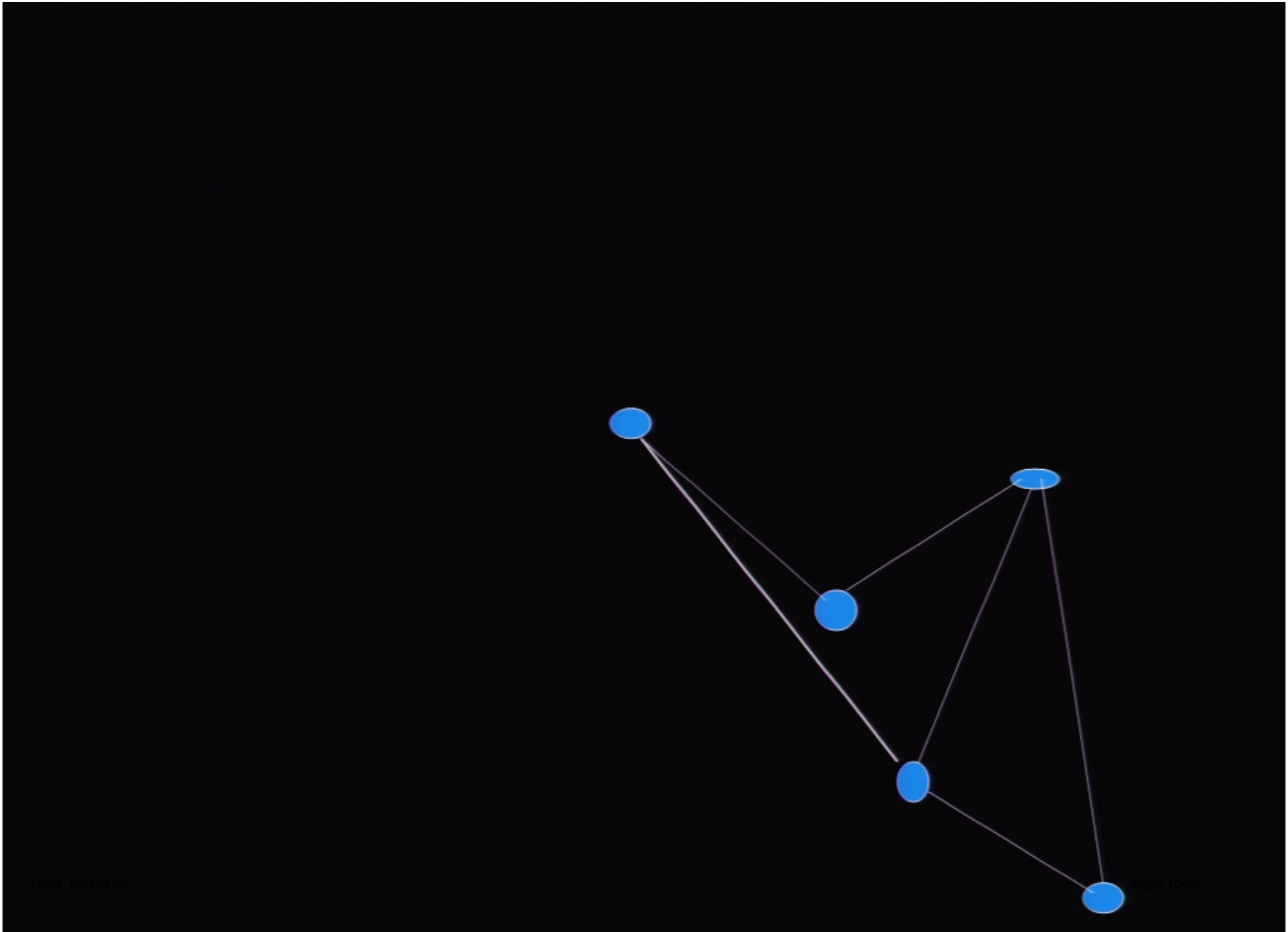
Samuel Clarke

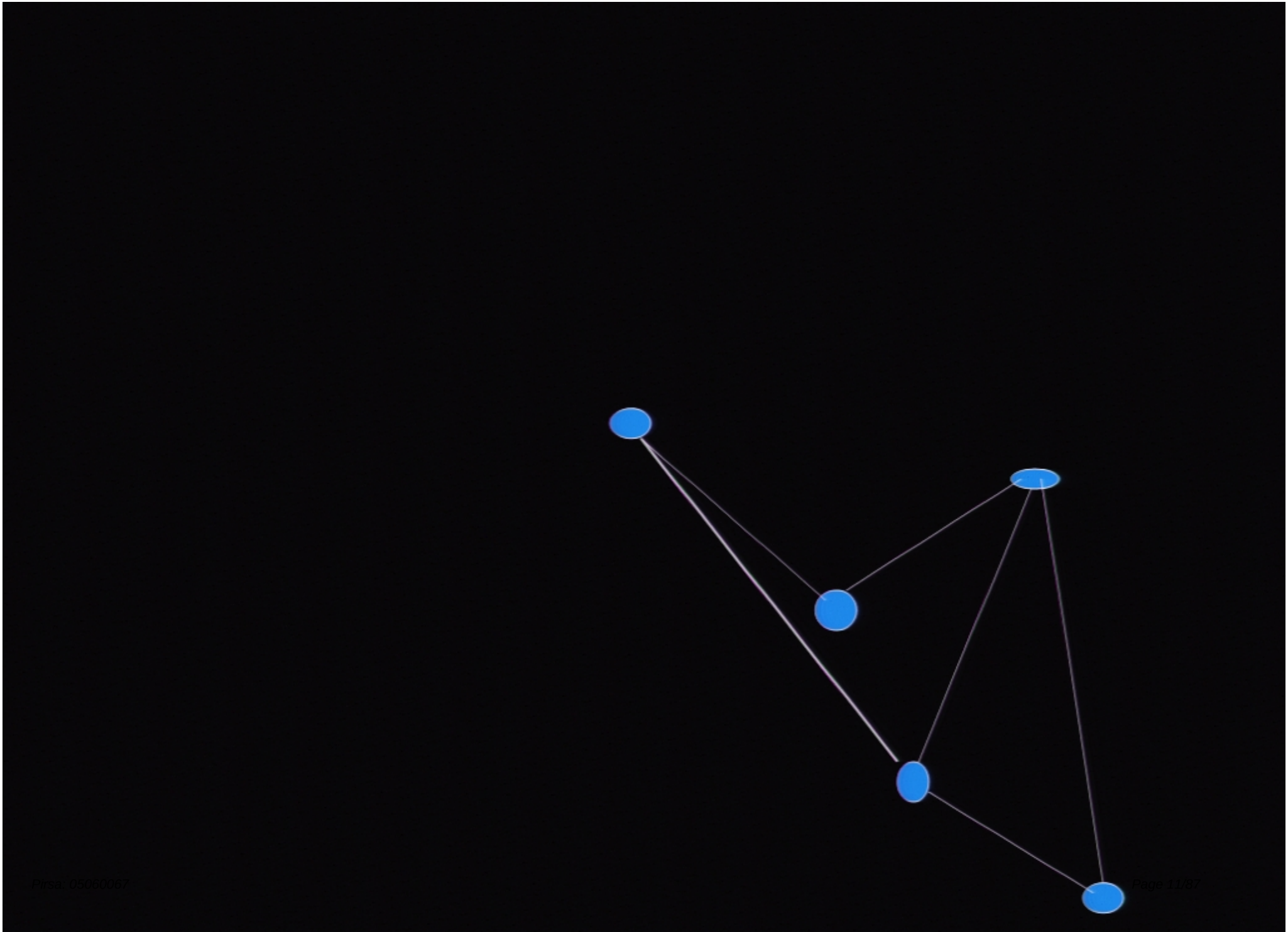
Space is something absolutely uniform; and, without the things placed in it, one point of space does not absolutely differ in any respect whatsoever from another point of space. Now from hence it follows, that 'tis impossible there should be a reason, why God, preserving the same situations of bodies among themselves, should have placed them in space after one certain particular manner, and not otherwise; why everything was not placed the quite contrary way, for instance, by changing East into West. But if space is nothing else, but that order or relation; and is nothing at all without bodies, but the possibility of placing them; then those two states, the one such as it now is, the other supposed to be quite the contrary way, would not at all differ from one another.

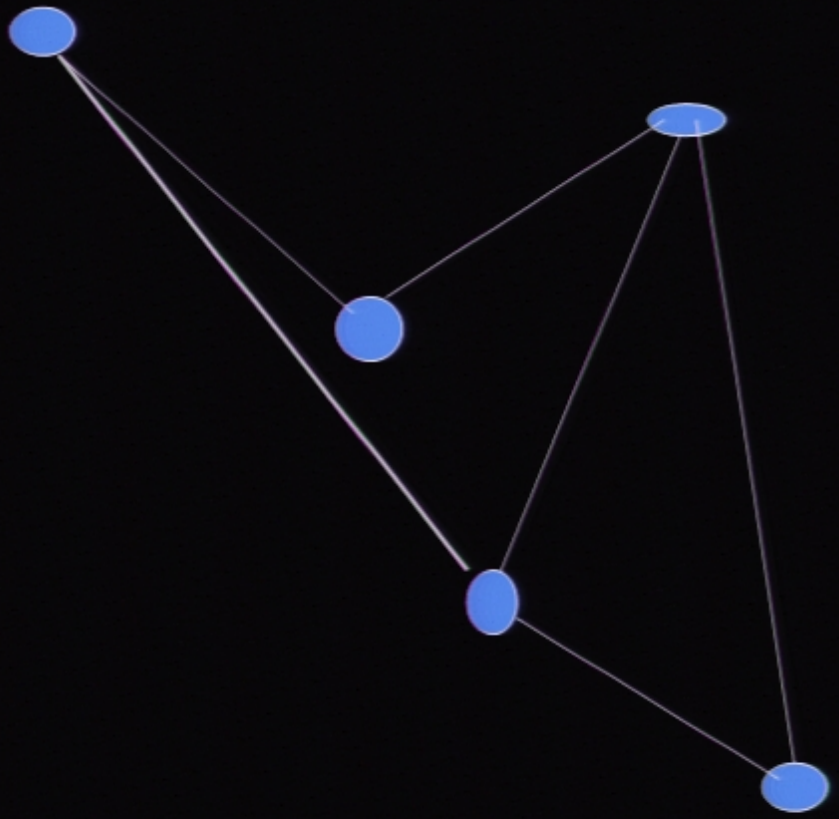
Leibniz, *Correspondence*

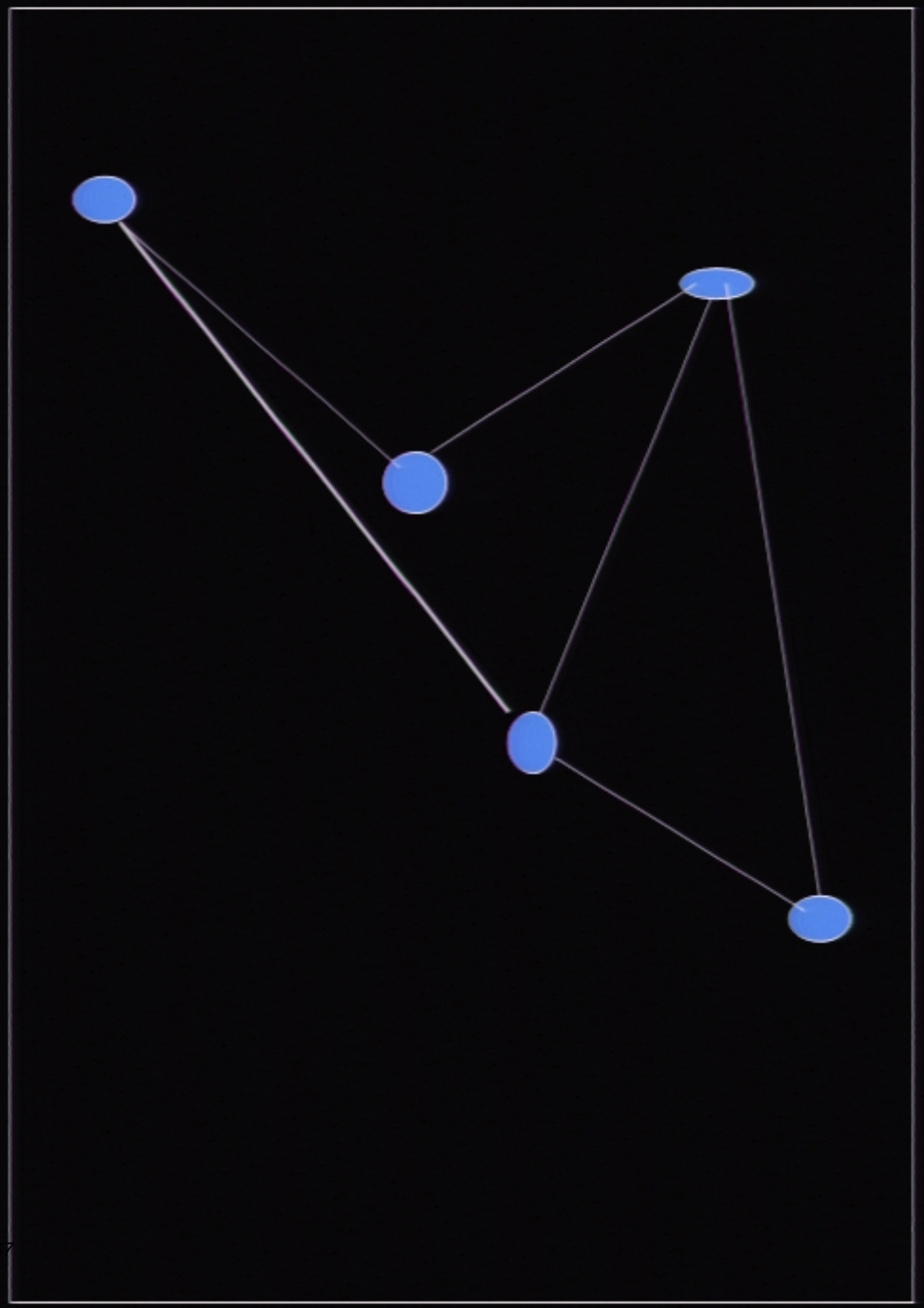


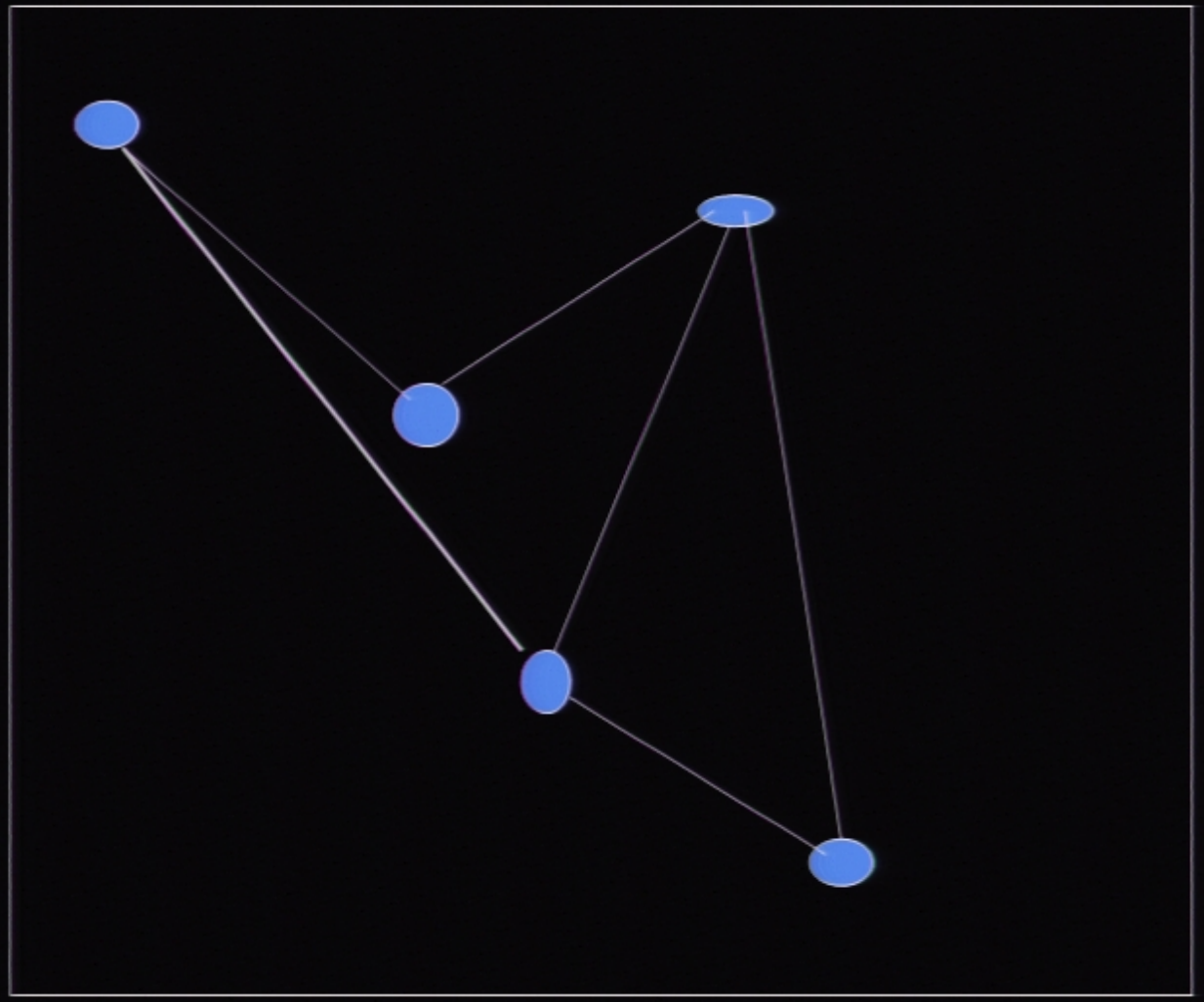


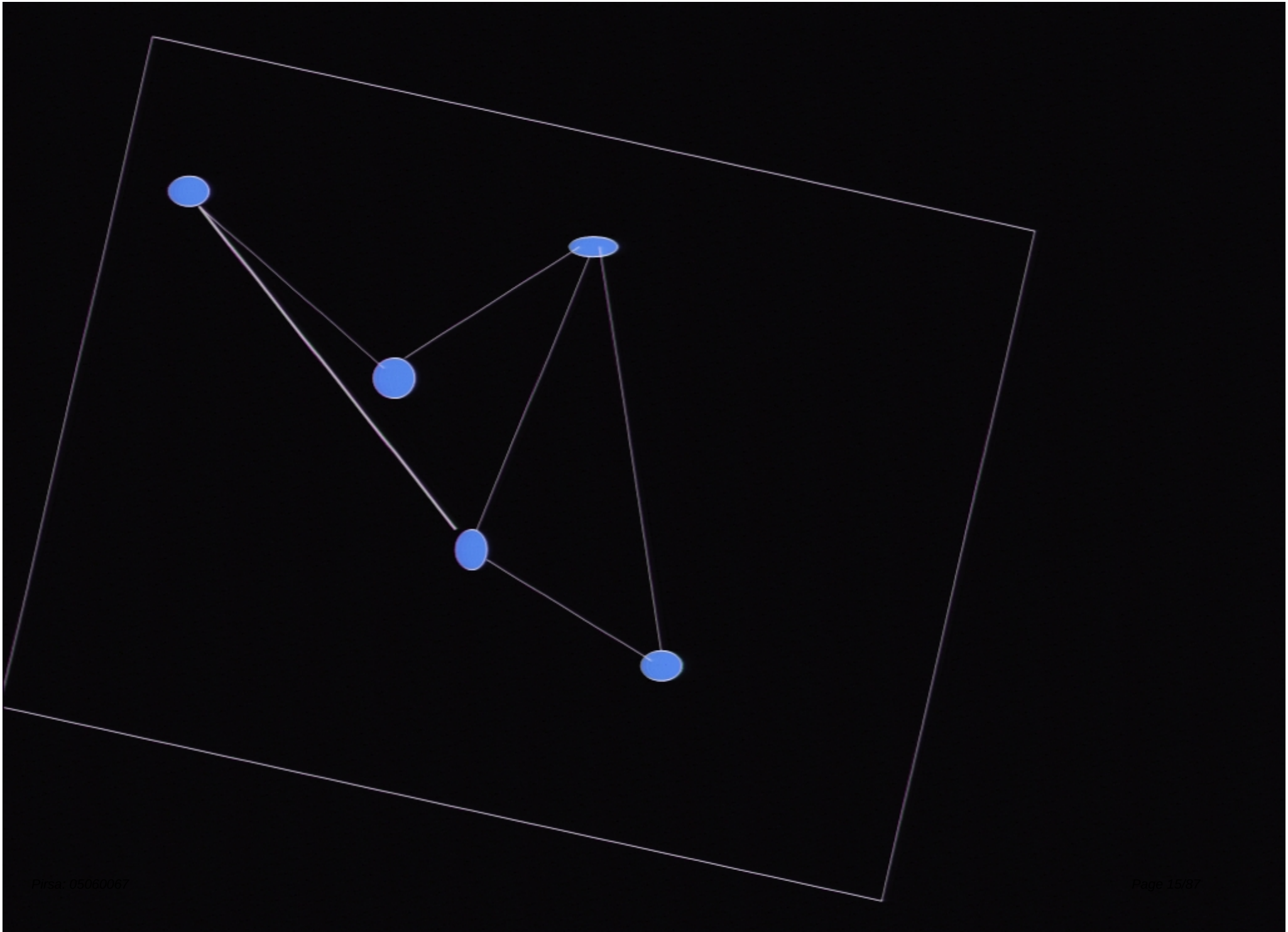












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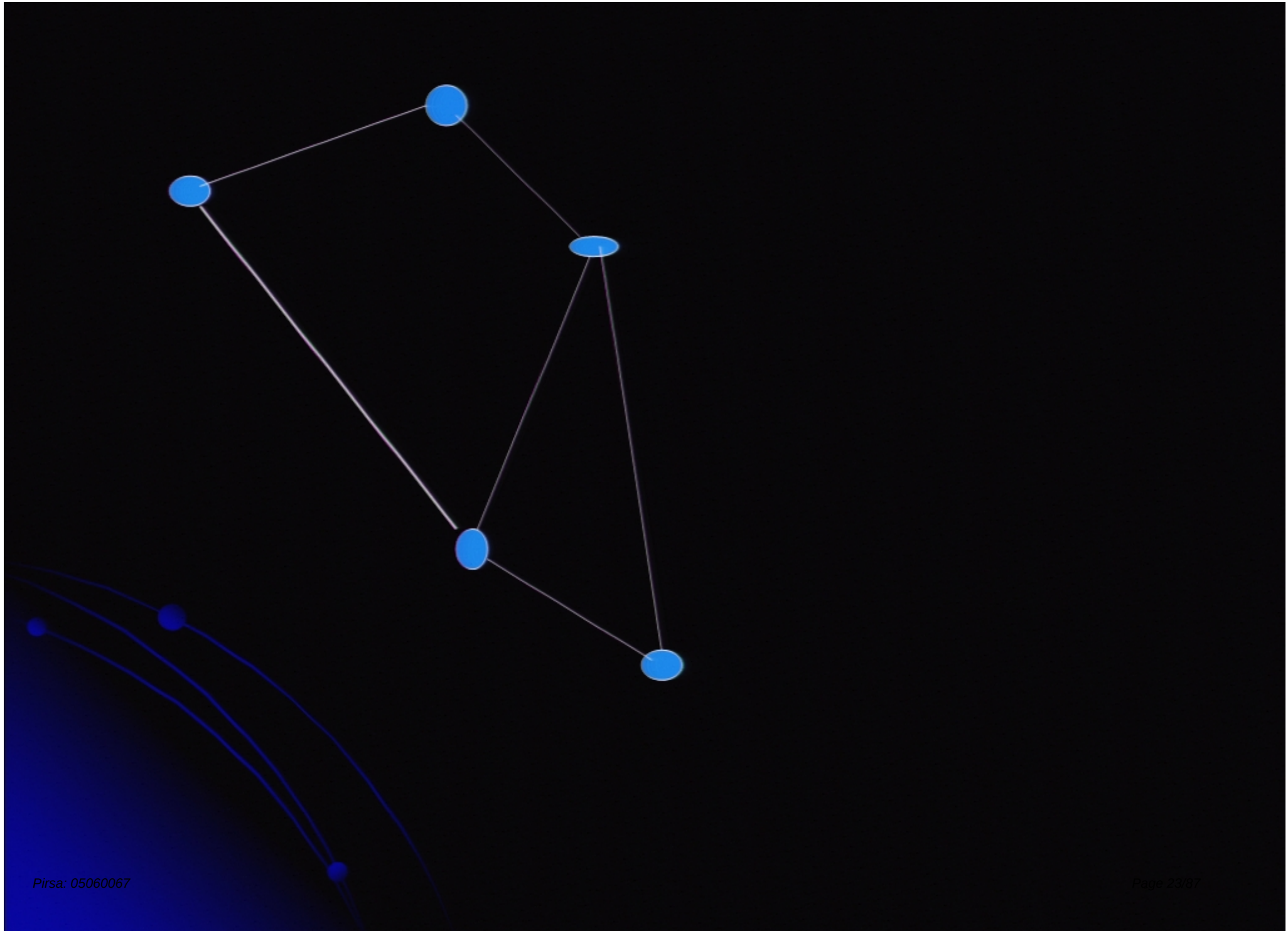

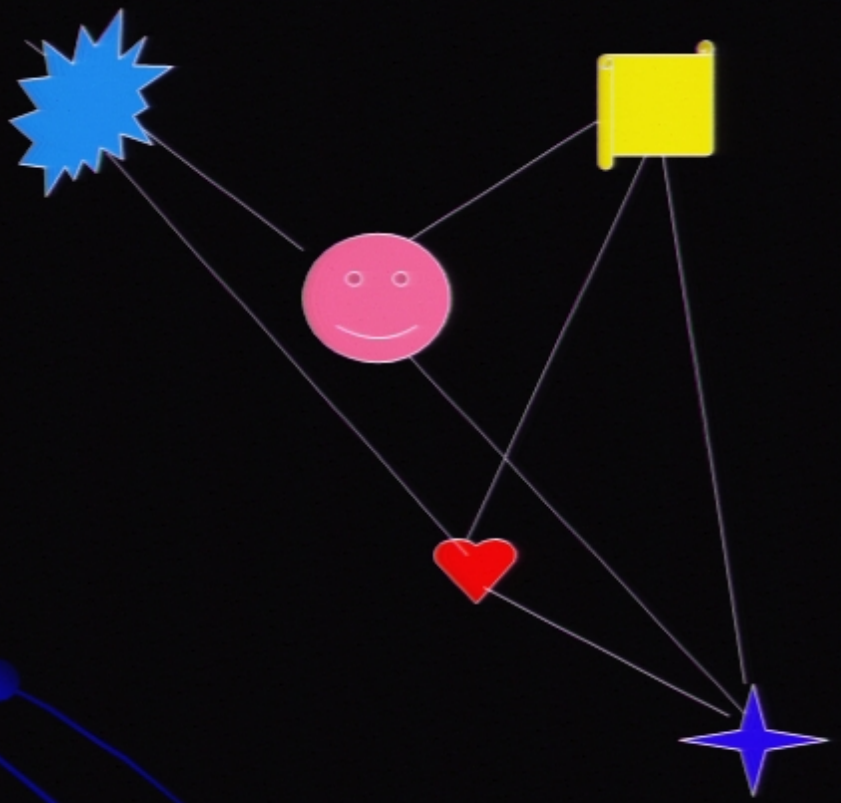

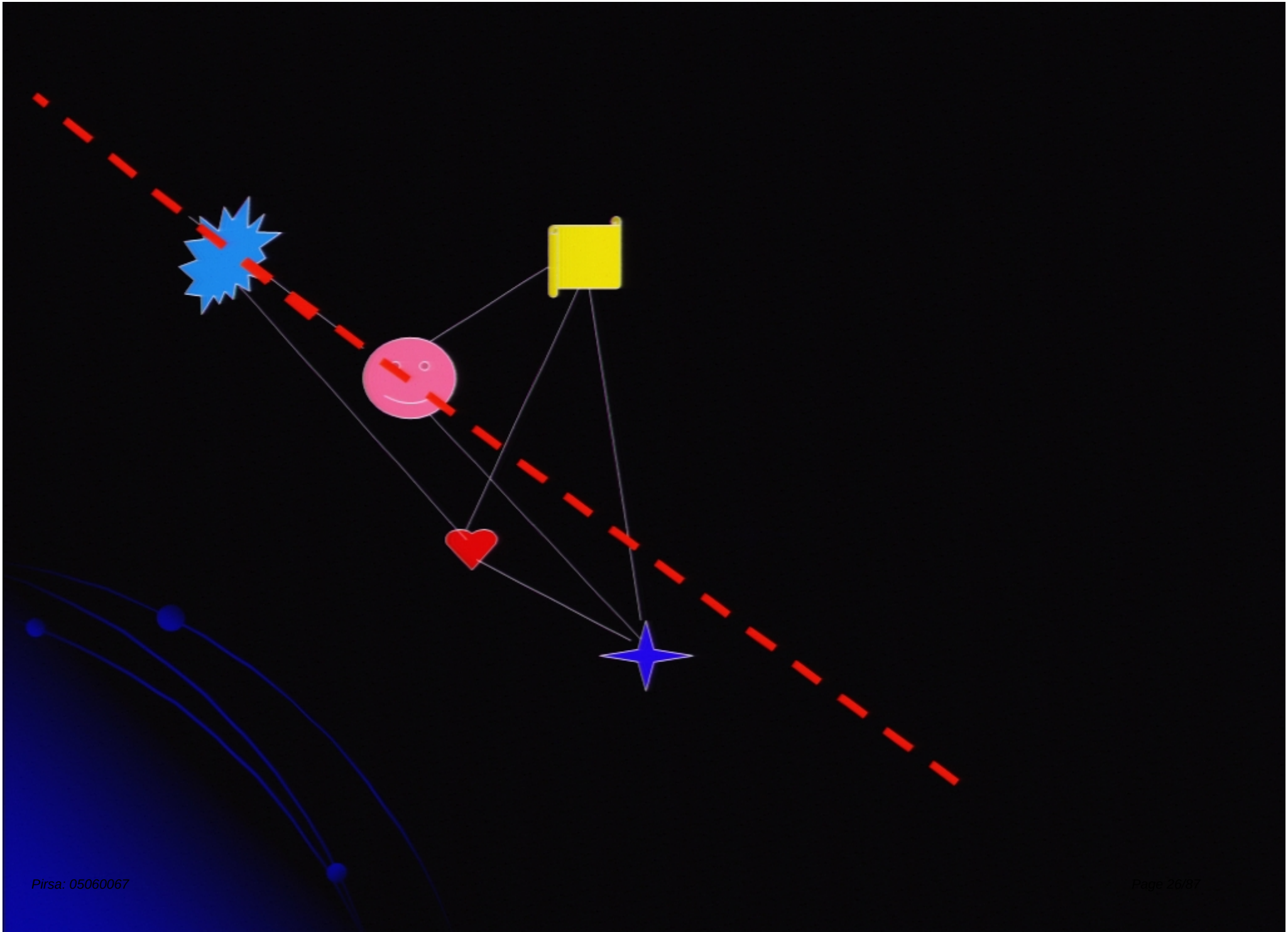

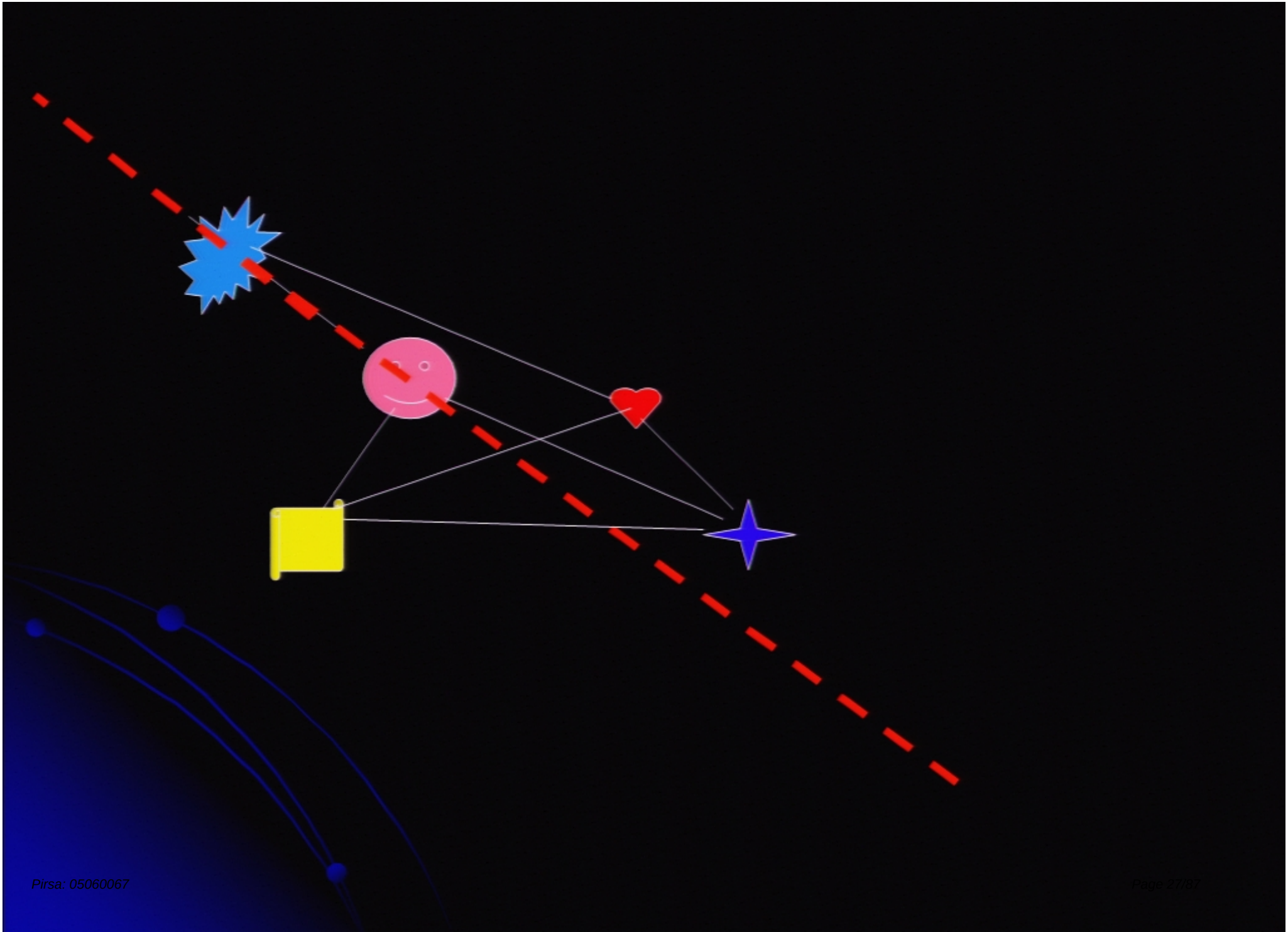

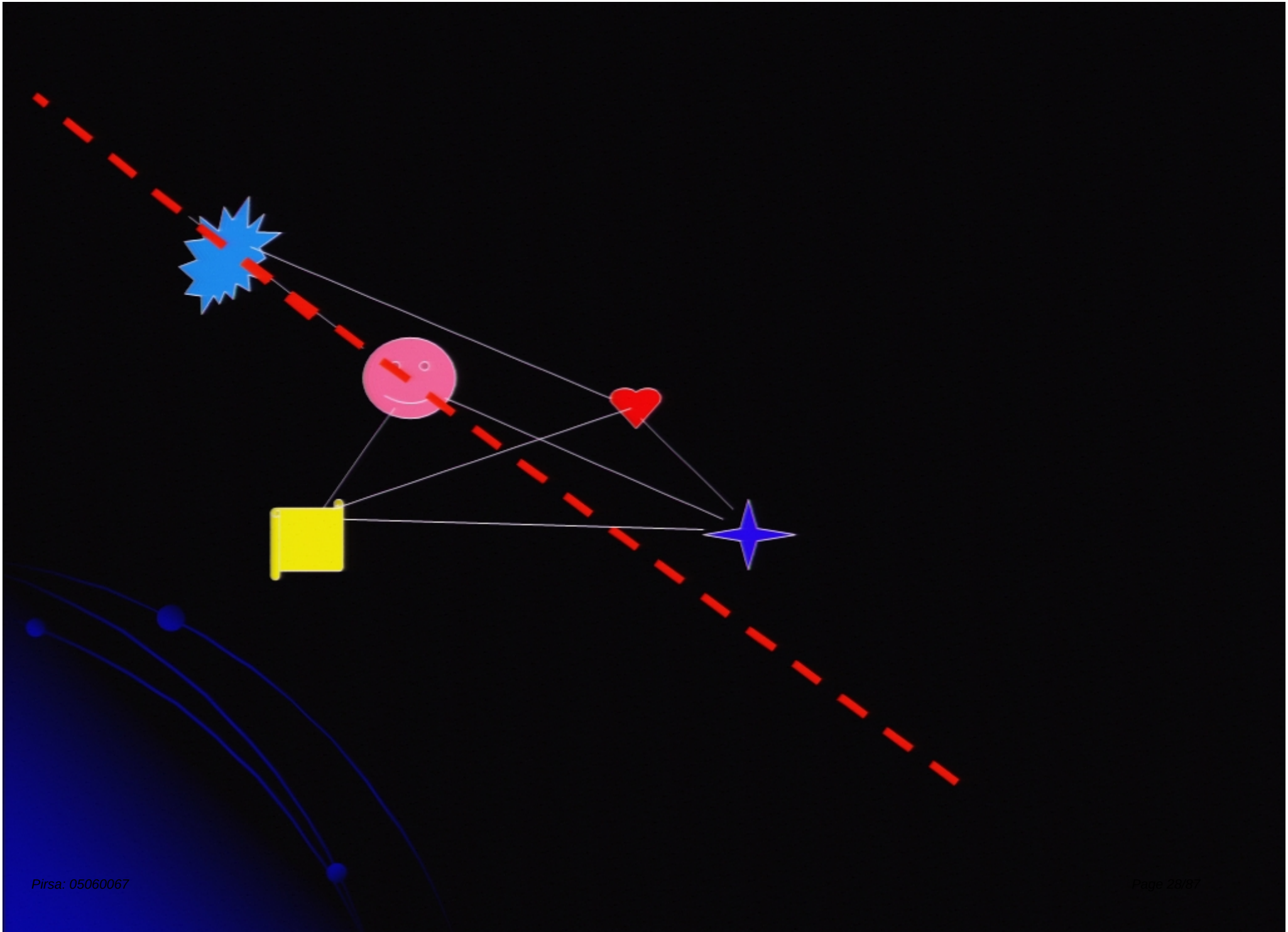

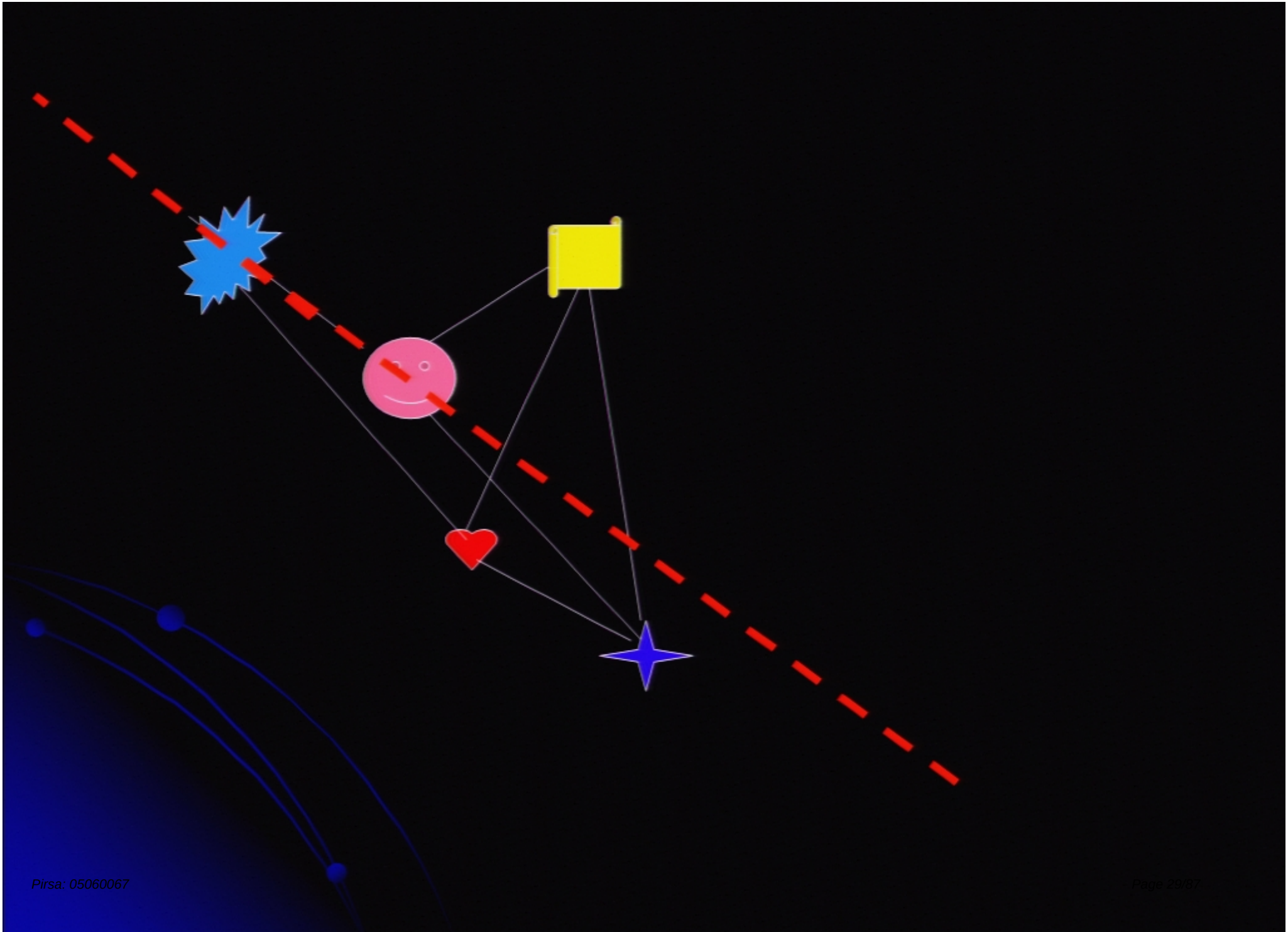

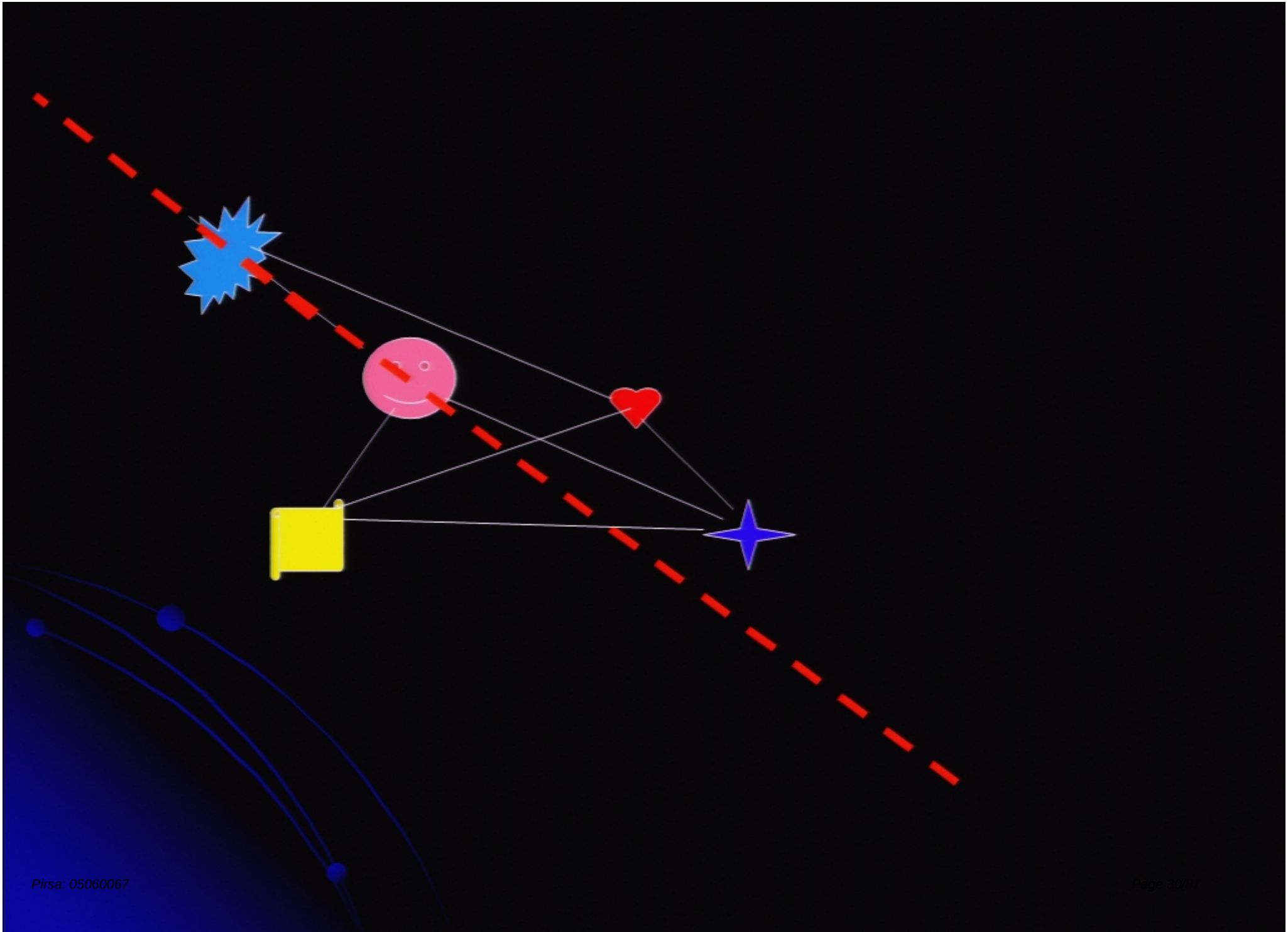

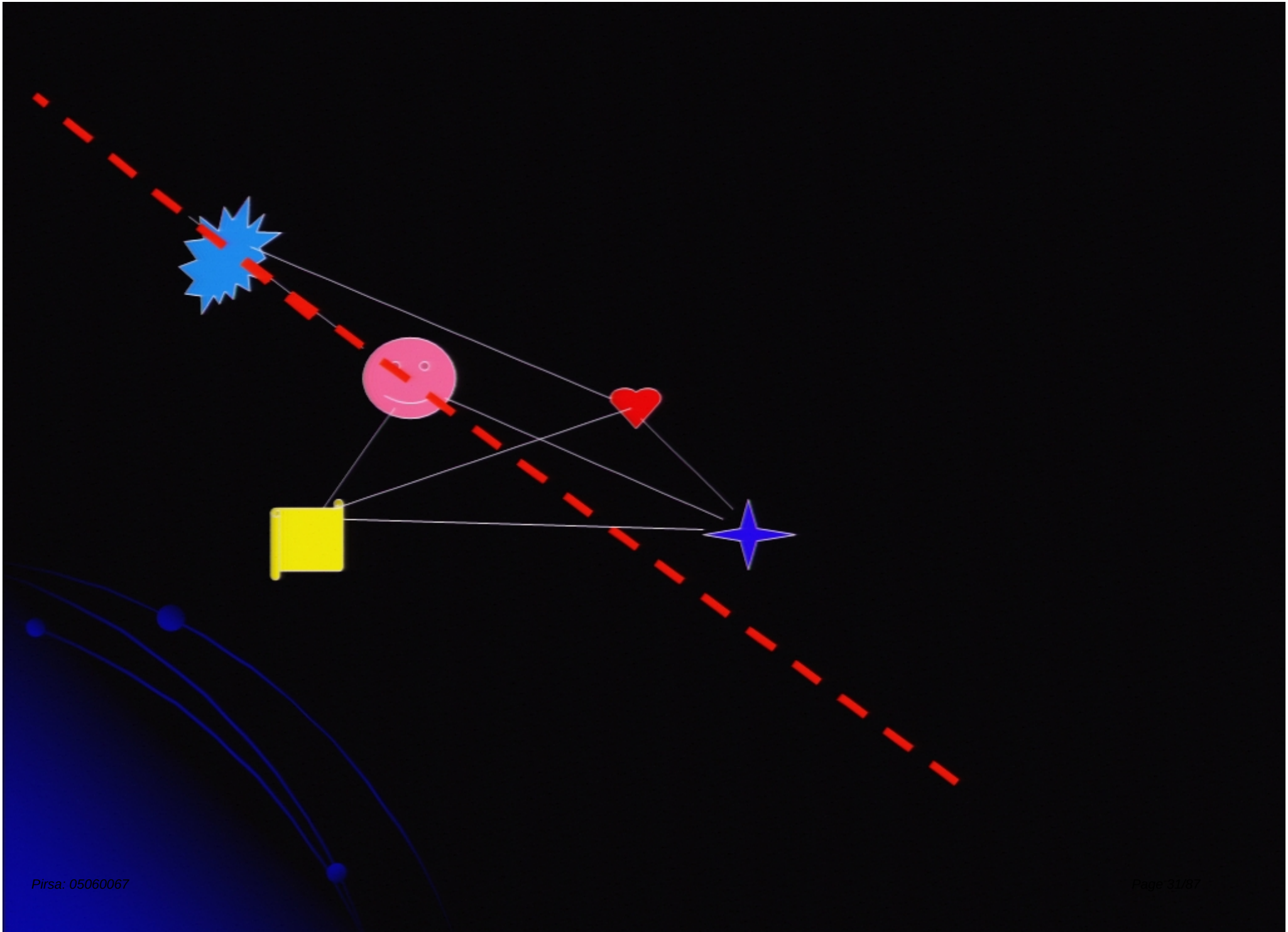

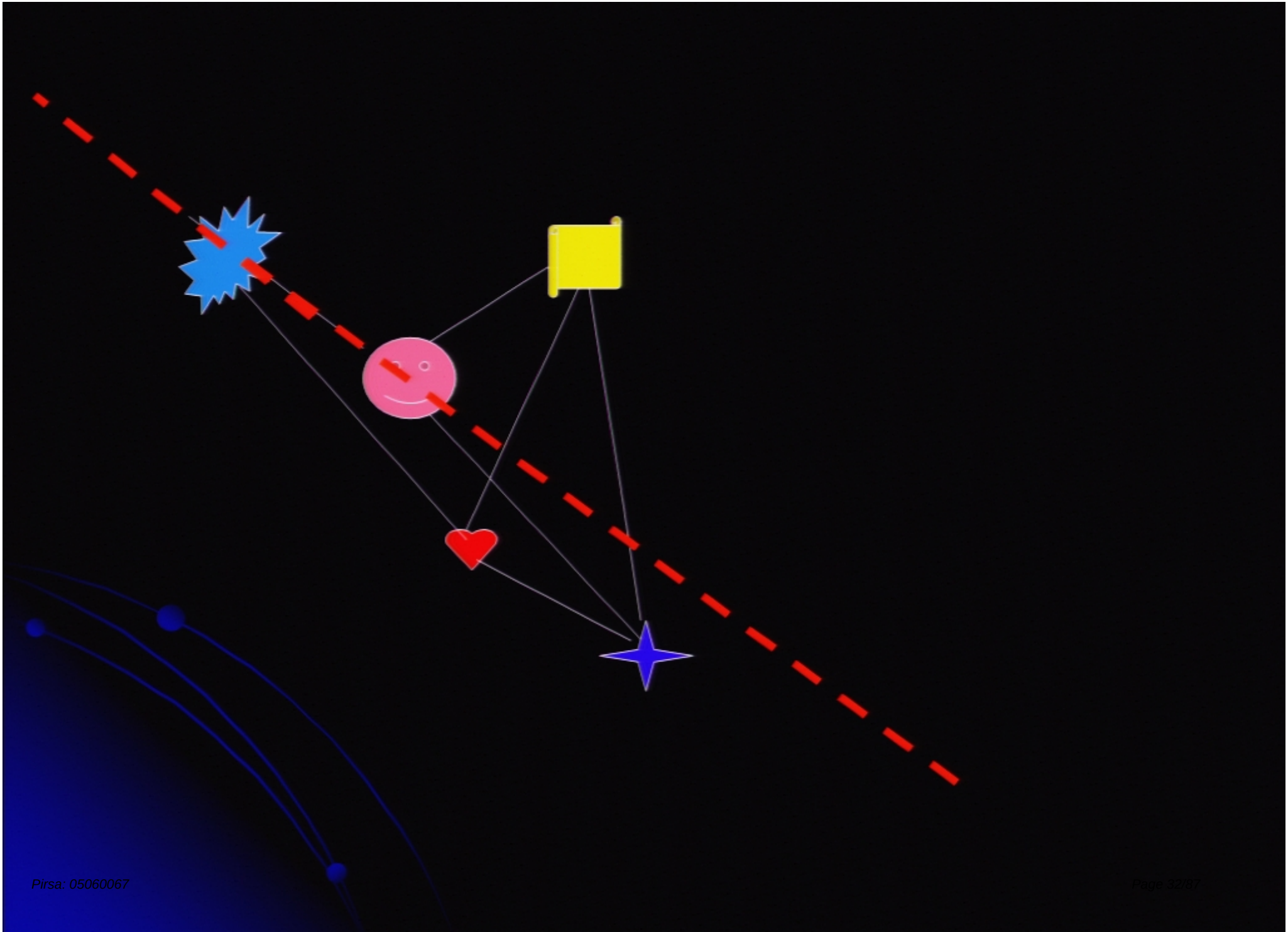

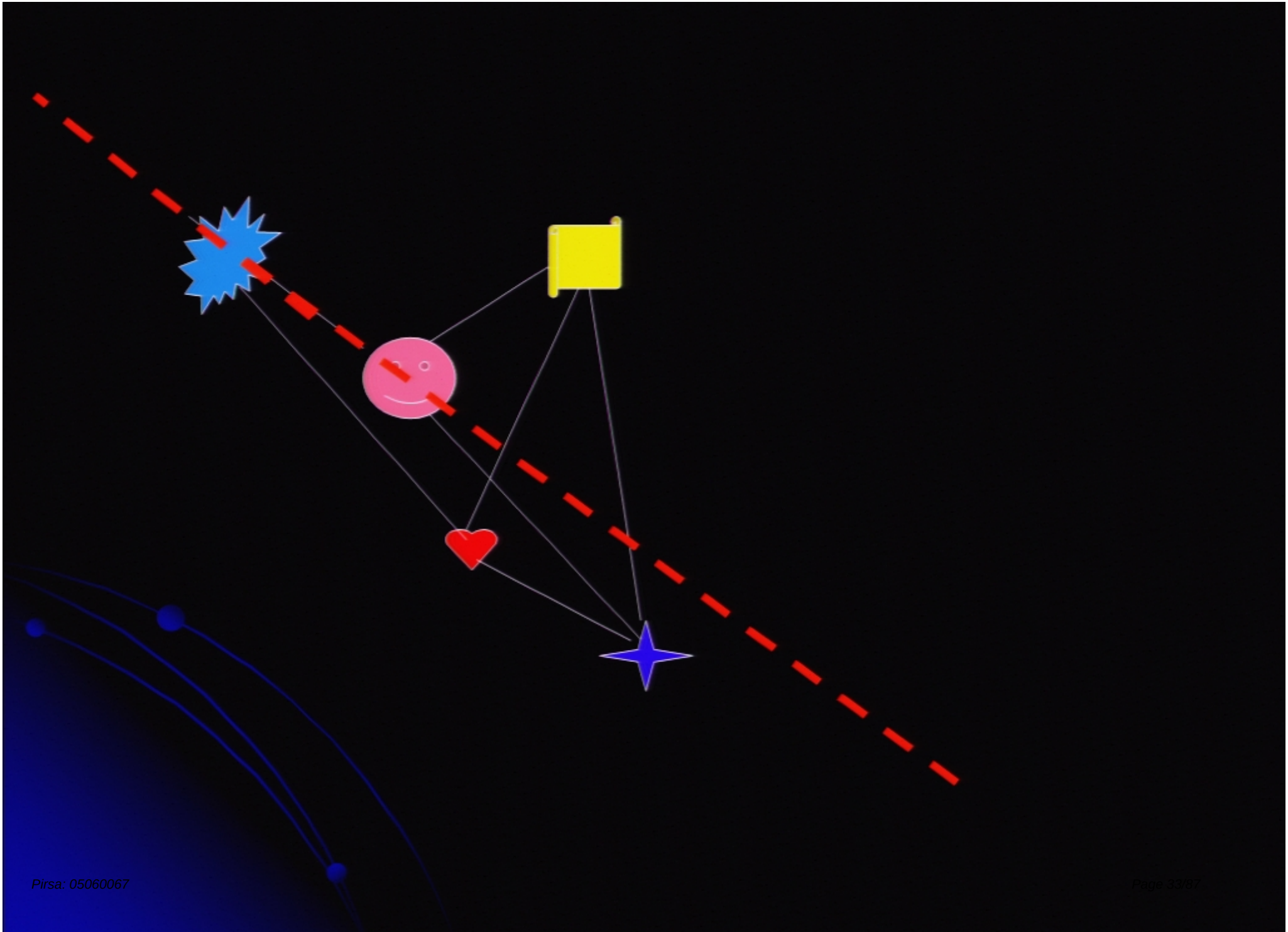

…….Space is something absolutely uniform; and, without the things placed in it, one point of space does not absolutely differ in any respect whatsoever from another point of space. Now from hence it follows, that 'tis impossible there should be a reason, why God, preserving the same situations of bodies among themselves, should have placed them in space after one certain particular manner, and not otherwise; why everything was not placed the quite contrary way, for instance, by changing East into West. But if space is nothing else, but that order or relation; and is nothing at all without bodies, but the possibility of placing them; then those two states, the one such as it now is, the other supposed to be quite the contrary way, would not at all differ from one another.

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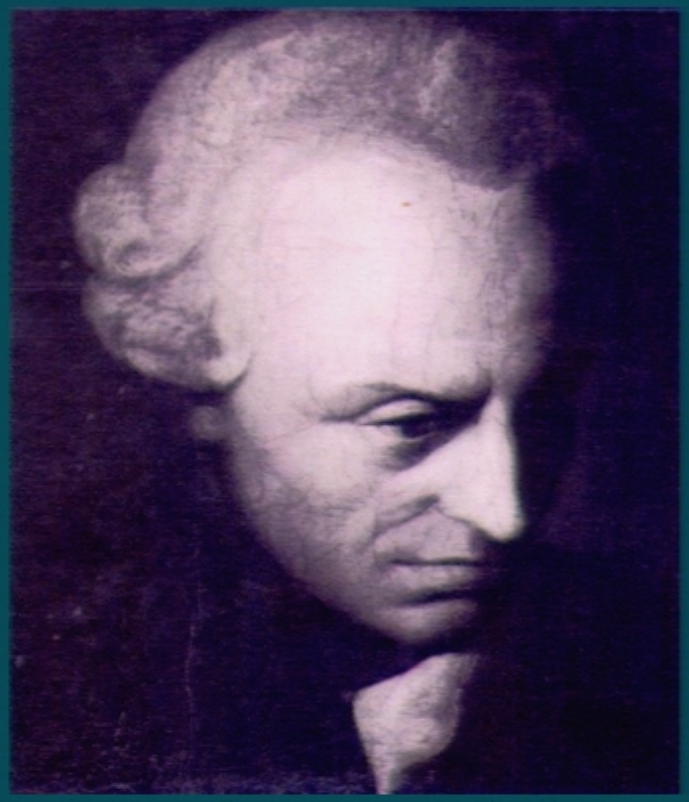
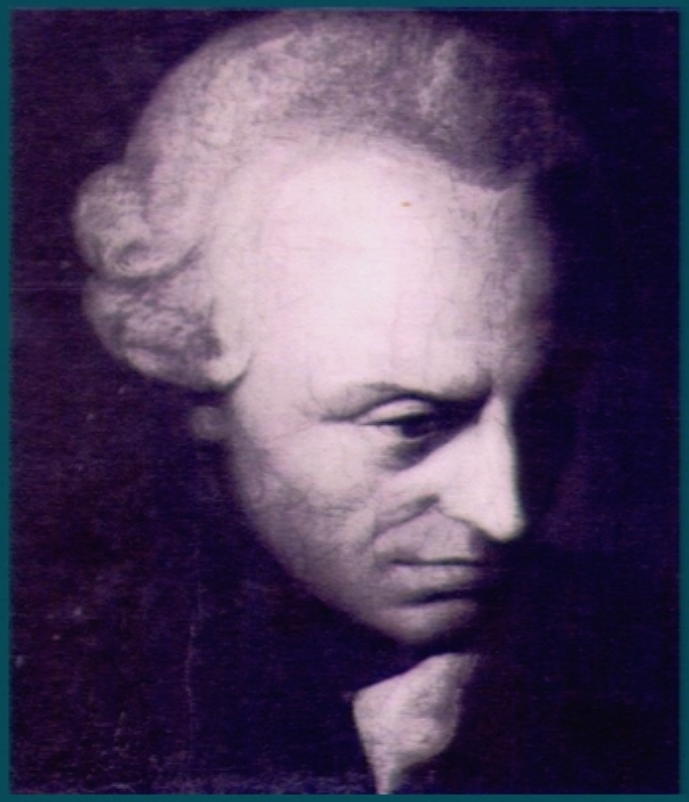
Immanuel Kant



It is apparent from the ordinary example of the two hands that the shape of the one body may be perfectly similar to the shape of the other, and the magnitudes of their extensions may be exactly equal, and yet there may remain an inner difference between the two, this difference consisting in the fact, namely, that the surface which encloses the one cannot possibly enclose the other. Since the surface which limits the physical space of the one body cannot serve as a boundary to limit the other, no matter how that surface be twisted and turned, it follows that the difference must be one which rests upon an inner ground.

Immanuel Kant



This inner ground cannot, however, depend on the difference of the manner in which the parts of the body are combined with each other. For, as we have seen from our example, everything may in this respect be exactly the same. Nevertheless, imagine that the first created thing was a human hand. That human hand would have to be either a right hand or a left hand. The action of the creative cause in producing the one would have of necessity to be different from the action of the creative cause producing the counterpart.

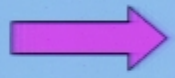
Immanuel Kant

Thus, between solid bodies which are perfectly similar and equal but incongruent, such as the left and right hands (in so far as they are conceived only according to their extension), or spherical triangles from two opposite hemispheres, there is a difference, in virtue of which it is impossible that the limits of their extension should coincide - and that, in spite of the fact that, in respect of everything which may be expressed by means of characteristic marks intelligible to the mind through speech, they could be substituted for one another. It is, therefore, clear that in these cases the difference between left and right can only be apprehended by a certain pure intuition.

hat space does not have more than three
limensions, that between two points there is only one
traight line, that from a given point on a plane surface
circle can be described with a given straight line,
tc. - none of these things can be derived from
ome universal concept of space; they can only be
pprehended concretely, so to speak, in space itself.

2 solutions to complete equations

the parallel.....

Positions in space  relative distances (invariant under translations)

the parallel.....

Positions in space → relative distances

left
right
→ congruent
anticongruent

the parallel.....

Positions in space → relative distances

left
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→ congruent
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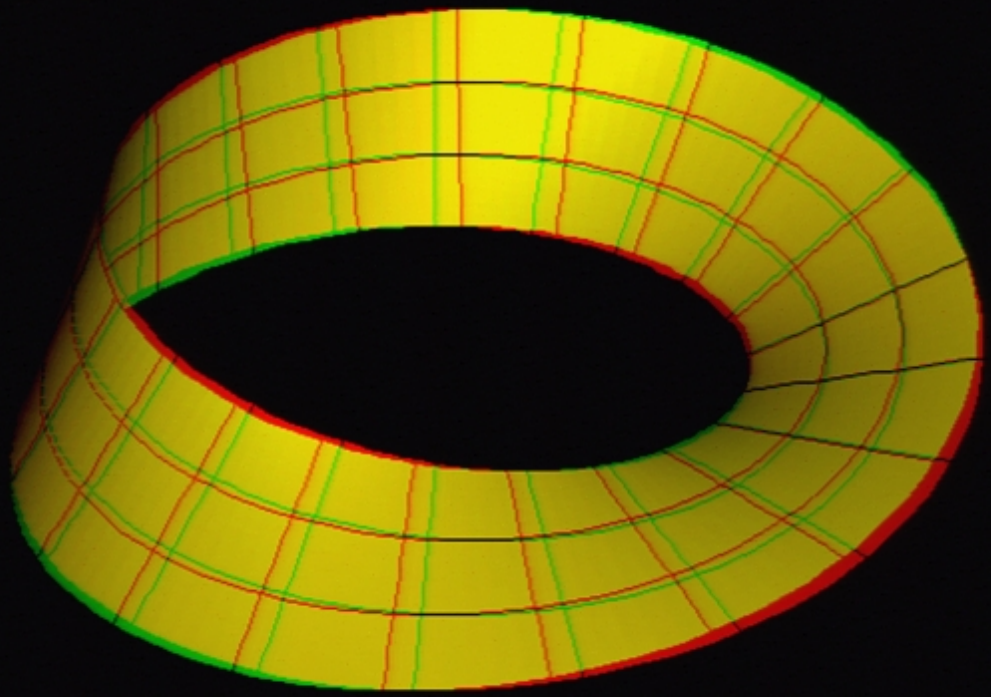
Moebius strip



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- That an object is handed or not handed
- That a handed object is congruent or anticongruent to another
- That certain handed objects like hands (screws, clocks, cars) are called ‘right’ (‘standard’, ‘clockwise’, ‘right-hand drive’)

According to Leibniz it would have made no difference if God had created a “right” hand first, rather than a “left”one. One must follow the world’s creation a step further, before a difference can appear. Had God, rather than making first a left, and then a right hand, started with a right hand, and then formed another right hand, he would have changed the plan of the universe, not in the first, but in the second act, in bringing forth a hand that was equally, rather than oppositely oriented to the first created specimen.

Hermann Weyl, *Symmetries*

How does mathematics handle symmetry?

- For a symmetry transformation g:f(x) →f(g.x) which leaves the mathematical structure unchanged
- Identify the two representations f(x) and
- f(g.x)
- Mathematical structures are only defined up to isomorphism

How does mathematics handle symmetry?

- Mathematical structures are only defined up to isomorphism
- Left and right do not differ intrinsically
- Other important example: i → -i

(complex conjugation: x+iy→x-iy)

- Time inversion: t→-t?

How does mathematics handle symmetry?

- $t\text{-}t^2$ not invariant under $t \rightarrow -t$
- there is no non-trivial automorphism of the real numbers

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- $t\text{-}t^2$ not invariant under $t \rightarrow -t$
- there is no non-trivial automorphism of the real numbers
- P, C, and T symmetries of relativistic quantum field theory are (mathematically) NOT on a par

the fall of parity

Tsung Dao Lee

Chien-Shiung Wu

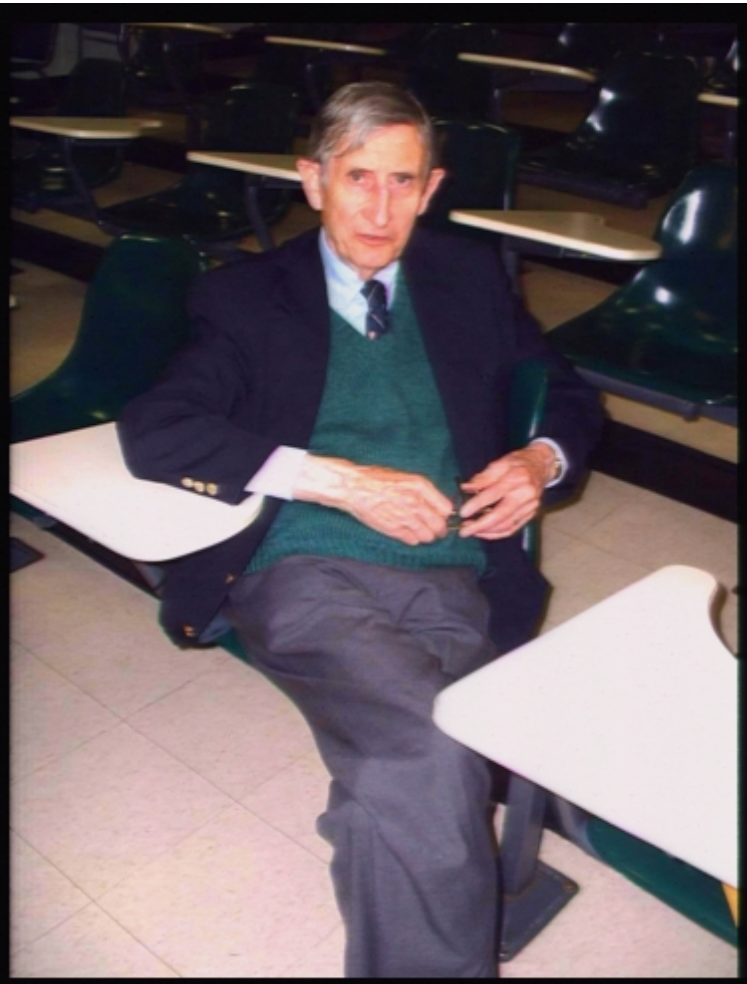
Chen Ning Yang

Pauli and Wu

Wolfgang Pauli: Now after the first shock is over, I begin to collect myself. Yes, it was very dramatic.

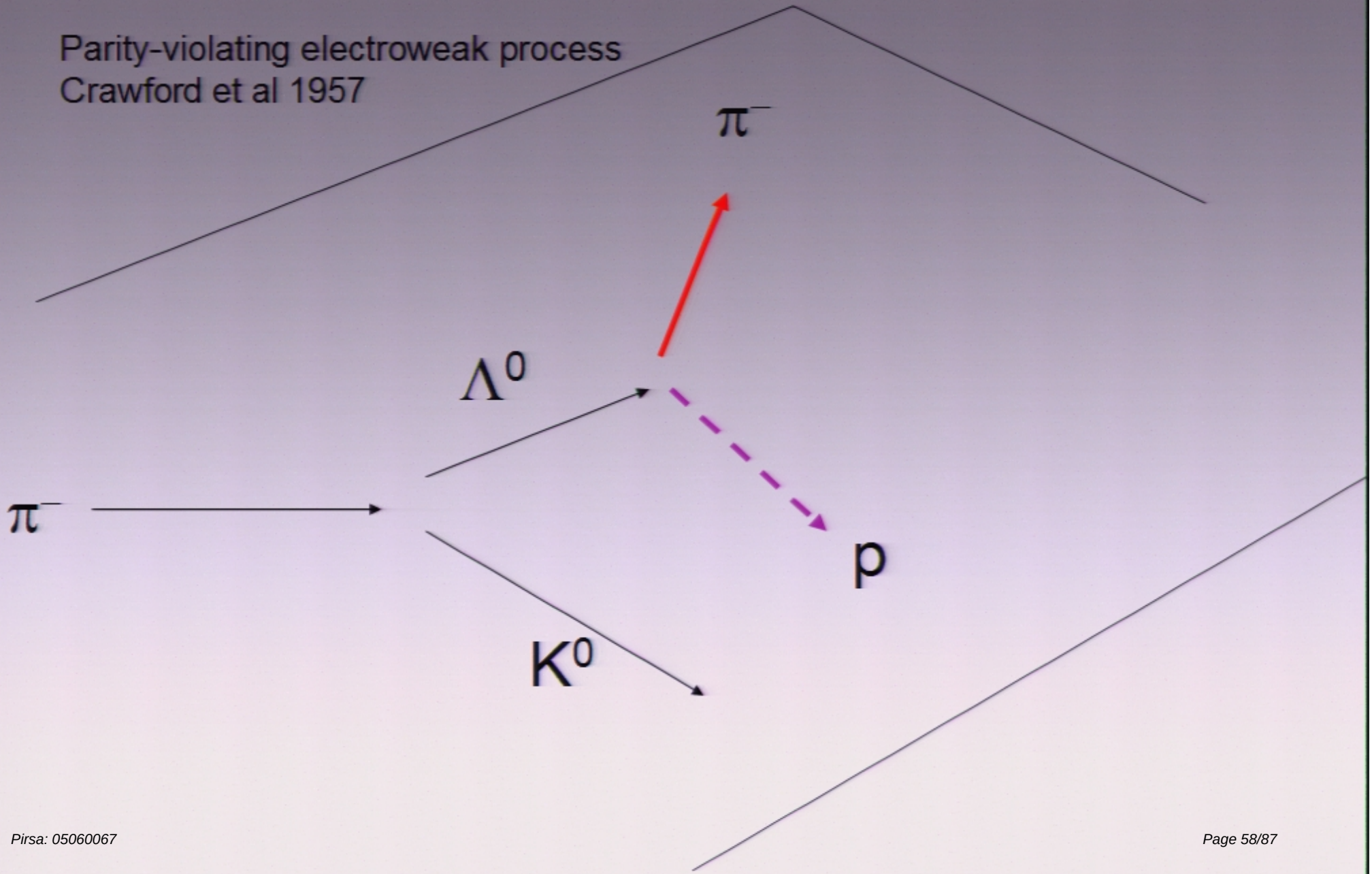
Isador Rabi: A rather complete theoretical structure has been shattered at the base and we are not sure how the pieces will be put together

Friedman Dyson

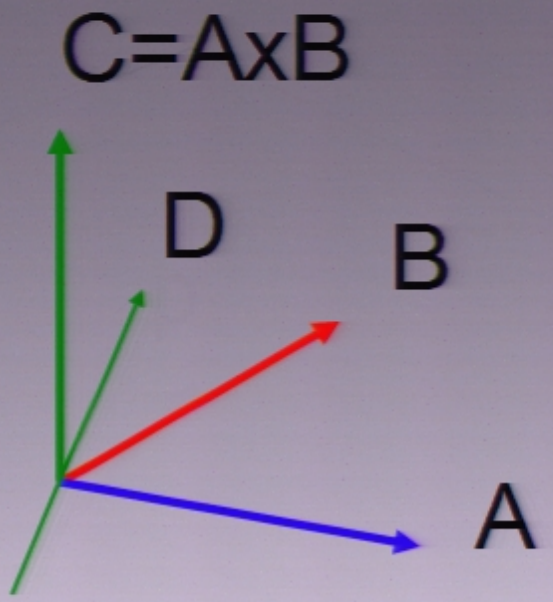


A copy of it was sent to me and I read it. I read it twice. I said, `This is very interesting,' or words to that effect. But I had not the imagination to say, `By golly, if this is true it opens up a whole new branch of physics.' And I think other physicists, with very few exceptions, at that time were as unimaginative as I

Parity-violating electroweak process
Crawford et al 1957

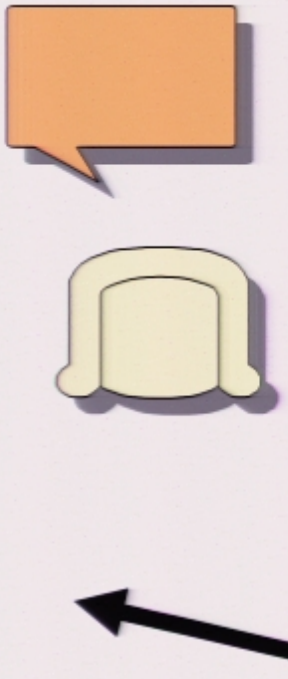


$(A \times B).D > 0$



2 possible worlds f(x), f(-x)

- World f(x)



- Mirror-world f(-x)

2 possible worlds f(x), f(-x)

(AxB)xD>0

(AxB)xD<0

- World f(x)

- Mirror-world f(-x)

2 possible worlds f(x), f(-x)

AxB “given”

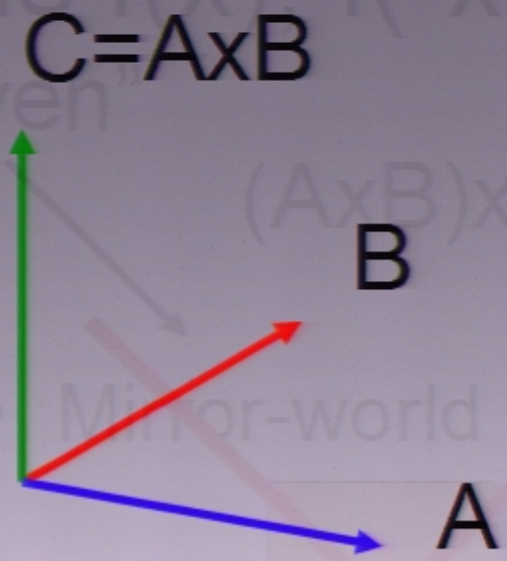
(AxB)xD>0

(AxB)xD<0

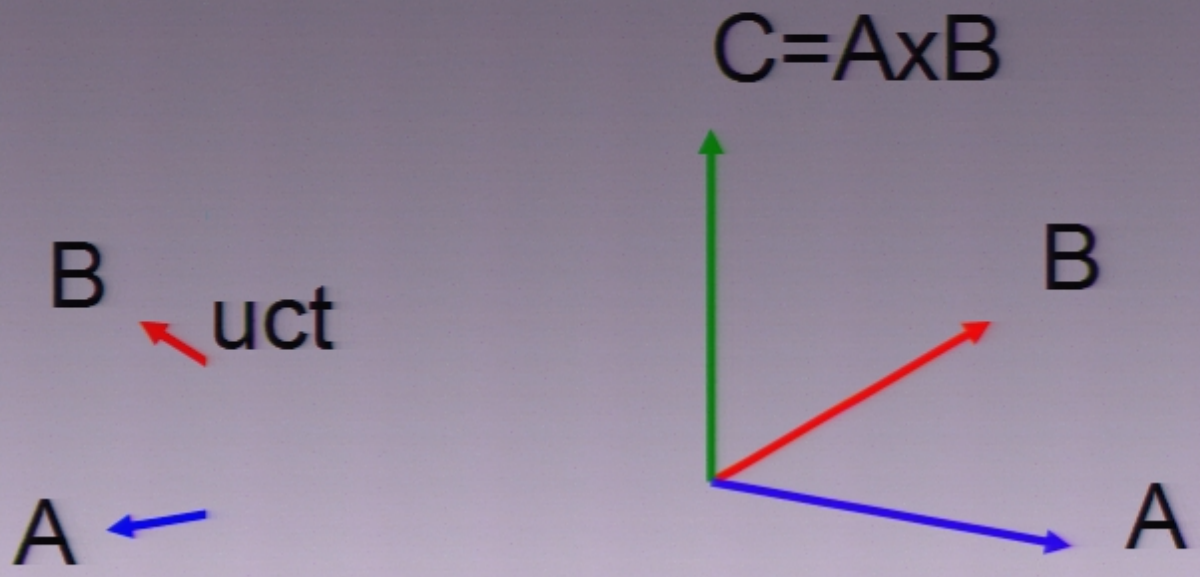
- World f(x)

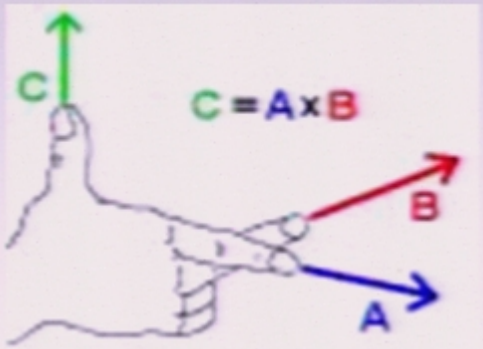
- Mirror-world f(-x)

How is the cross product defined?

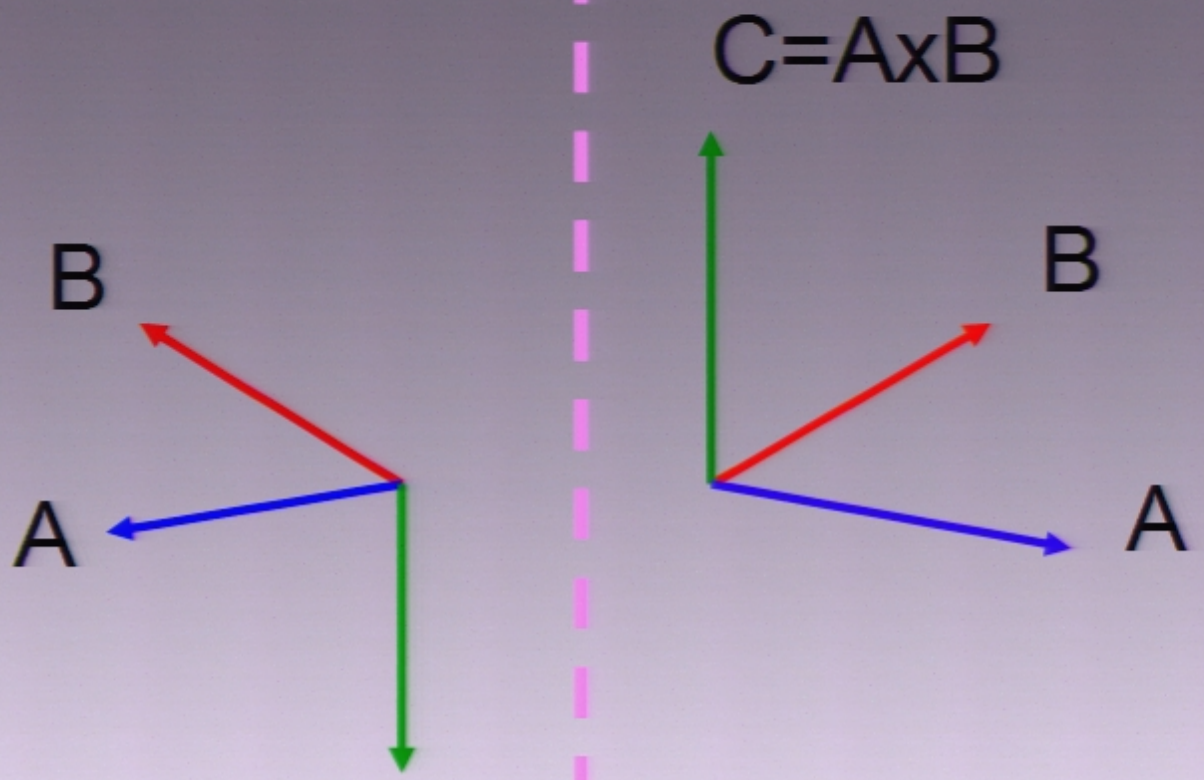


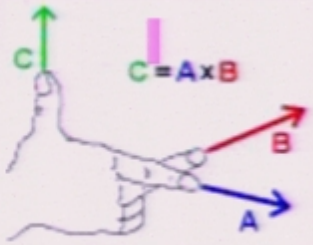
Mirrorii





Mirroring





Mirroring

C=AxB

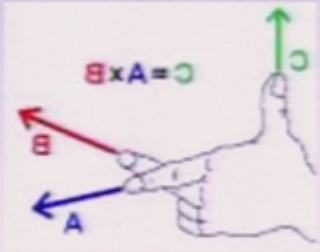
B

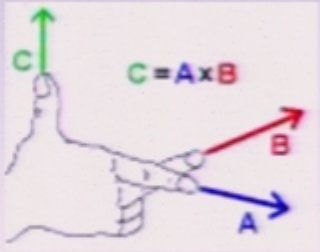
A

?

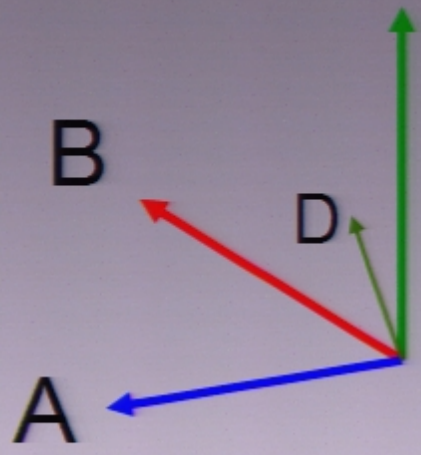
B

A





C=AxB



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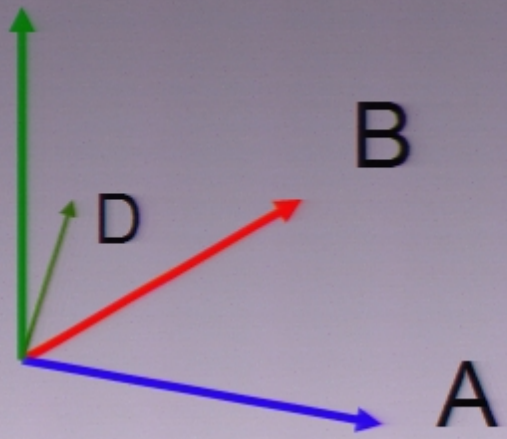
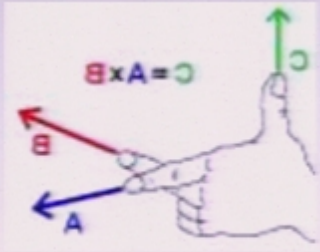
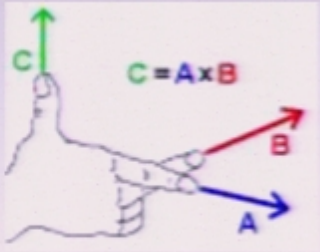
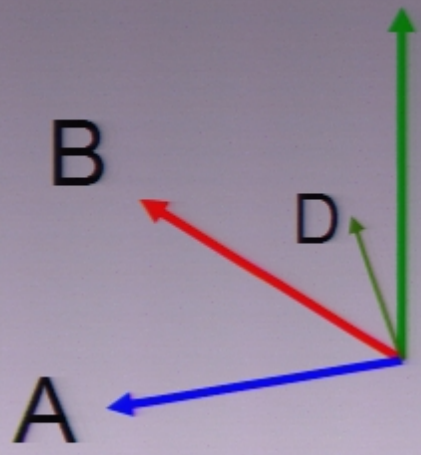


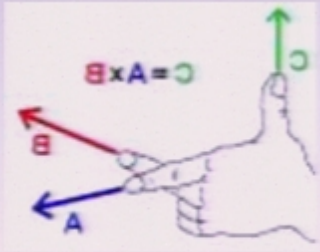




C=AxB



(AxB).D>0



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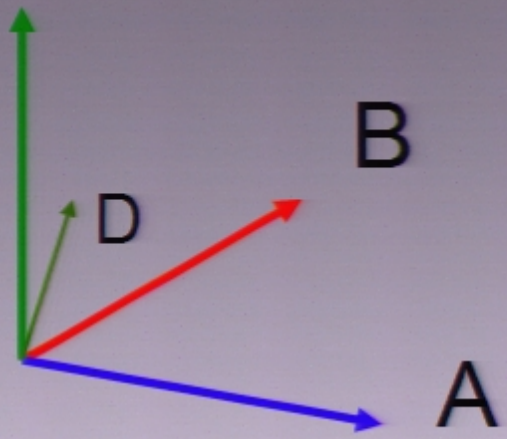

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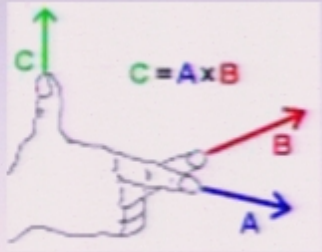


Mirroring

C=AxB

C=AxB

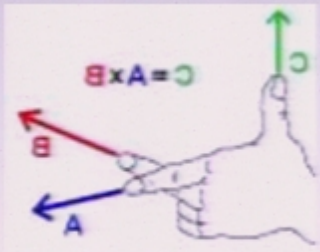
B

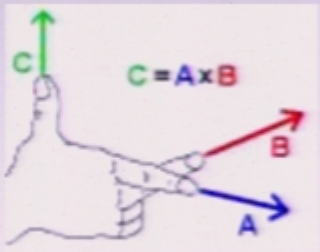
A

?

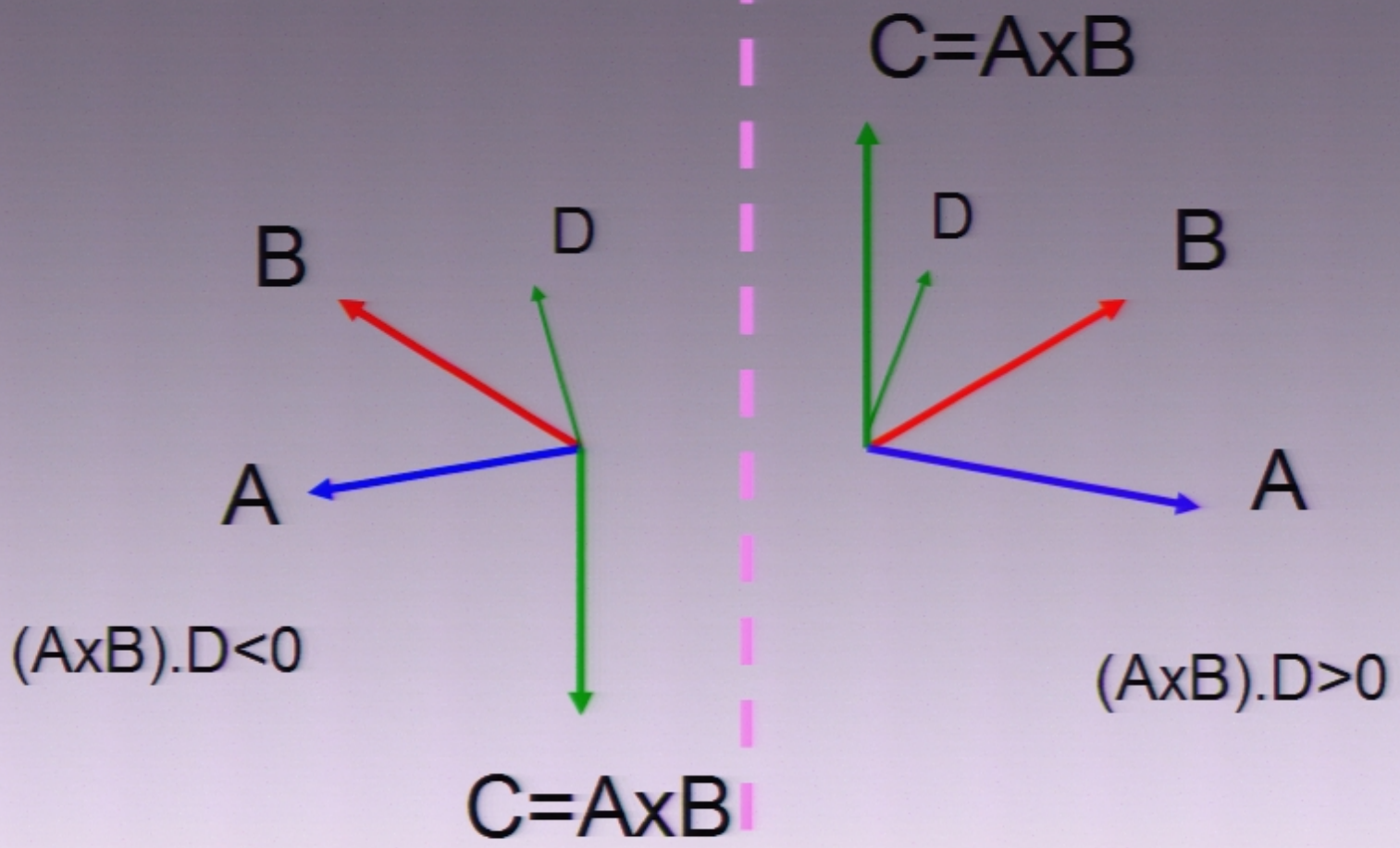
B

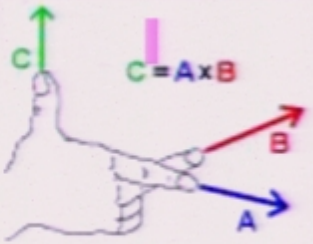
A





Mirroring





C=AxB

B

D

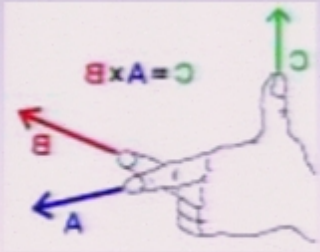
A

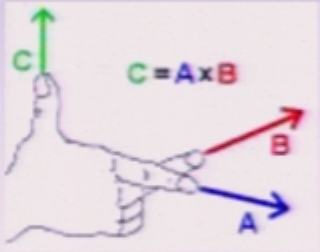
C=AxB

B

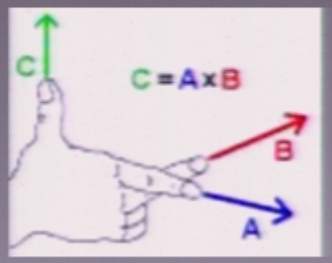
D

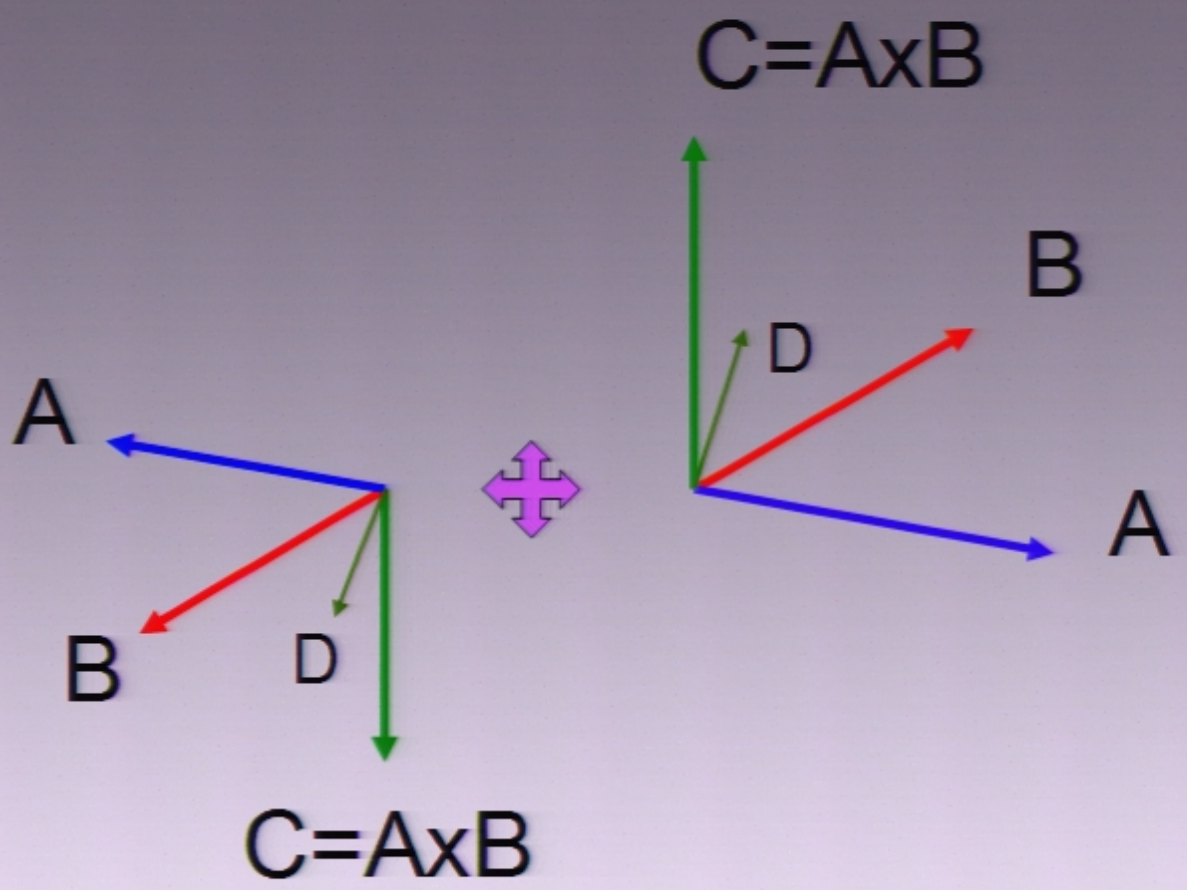
A

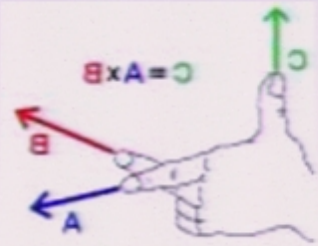




Inversion

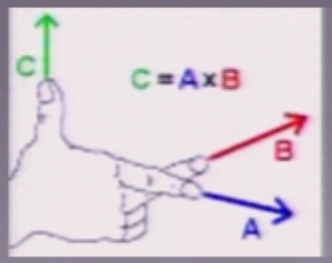


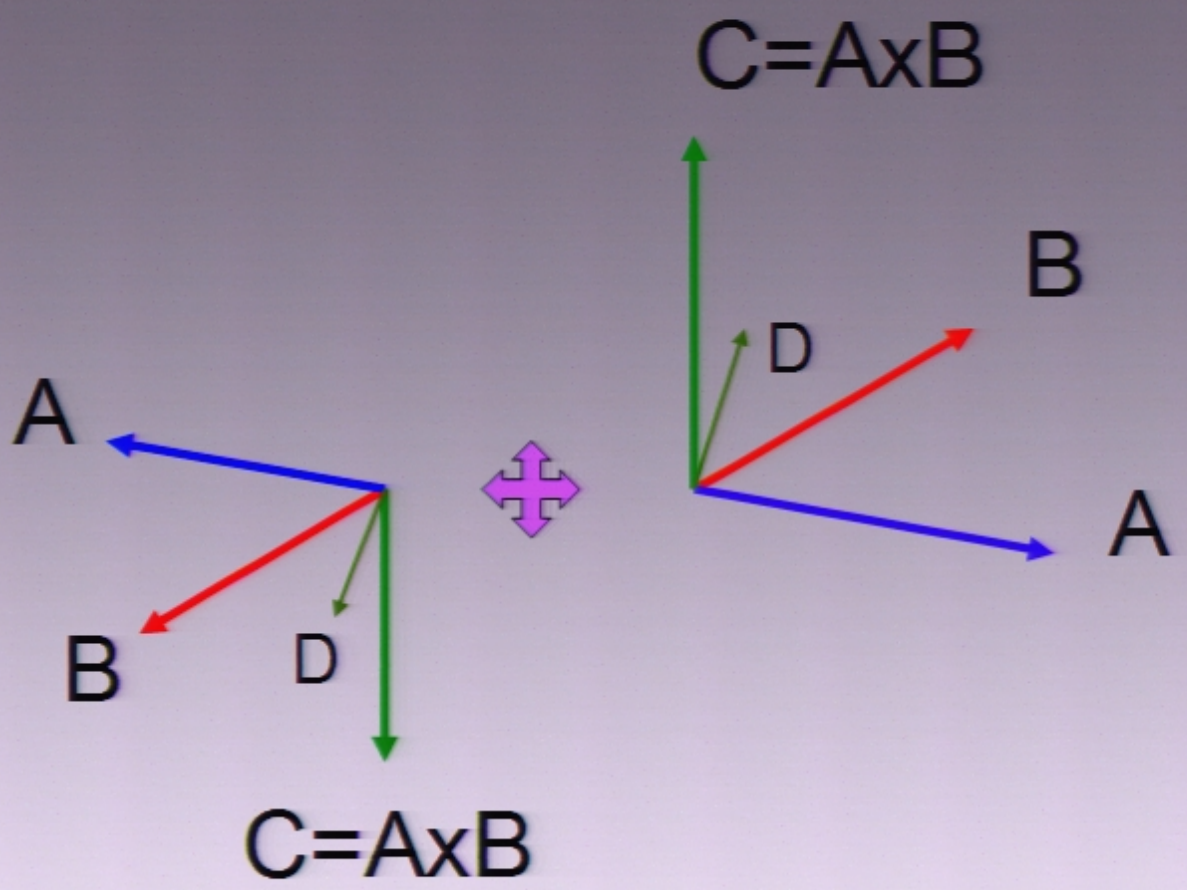


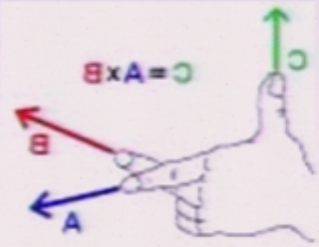


+ 180^0 rotation about wrist

Inversion



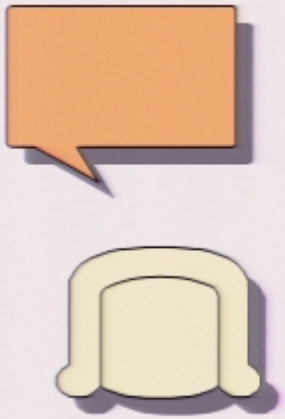




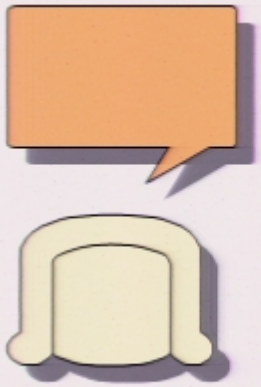
+ 180^0 rotation about wrist

2 possible worlds f(x), f(-x)

- World f(x)



- Mirror-world f(-x)



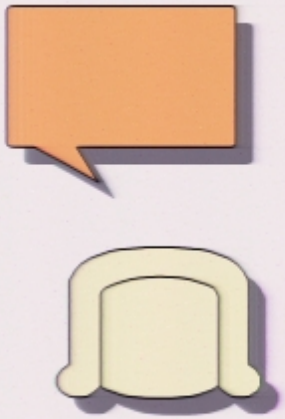
2 possible worlds f(x), f(-x)

AxB “given”

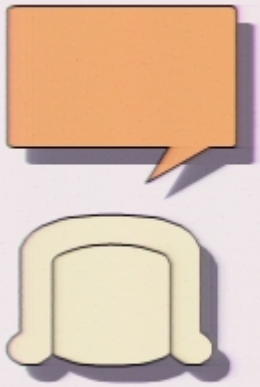
(AxB).D>0

(AxB).D<0

- World f(x)



- Mirror-world f(-x)



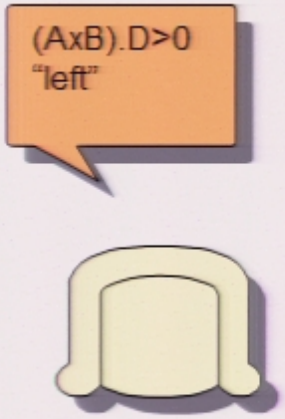
2 possible worlds f(x), f(-x)

AxB given

(AxB).D>0

(AxB).D<0

- World f(x)



- Mirror-world f(-x)

Violation of Principle of Sufficient reason

2 possible worlds f(x), f(-x)

AxB given

(AxB).D>0

(AxB).D<0

- World f(x)

(AxB).D>0
"left"

- Mirror-world f(-x)

(AxB).D>0
"left"

Under-determination

Two senses of mirror symmetry

Two senses of mirror symmetry

- Internal to worlds

Two senses of mirror symmetry

- Internal to worlds

(a priori symmetry)

Two senses of mirror symmetry

- Internal to worlds

(a priori symmetry)

- Identify worlds

(indistinguishable from within)

- External background

(broken symmetry)

- Distinguish worlds

Two senses of mirror symmetry

- Internal to worlds

(a priori symmetry)

- Identify worlds

(indistinguishable from within)

- External background

(broken symmetry)

- Distinguish worlds

(indistinguishable from within!)

Two senses of mirror symmetry

- Internal to worlds

(a priori symmetry)

- Identify worlds

(indistinguishable from within)

- Only meaningful use of cross-product etc.: in/congruence relations WITHIN a world

- External background

(broken symmetry)

- Distinguish worlds

(indistinguishable from within!)

Orientation should be defined…

…in absolute terms, not just relative to some arbitrary coordinates. Thus, not until an `arrow of space' is given is the theory well-defined. This arrow can tell us for two points whether their separation is positive or negative - which the `earlier' spatially speaking - and hence give definite meaning to the Hamiltonian of the theory. (Note the analogy with Newton's first law: `constant motion', and thus the law, is ill defined unless some notion of affine structure is given.) Of course, once we have observed the development of the particles we could determine the direction of the arrow, and could express its direction in relational terms, say by two standard objects and their order. …the relationist is not faced with a descriptive problem - or even an epistemological problem - but with formulating a theory of the process in suitable relational terms, and a plausible theory should not make fundamental reference to a contingent standard. (Huggett BJPS, 1999, p.16).

So we can introduce an orientation field to ground a local explanation of the non-local symmetries that the relationalist must postulate as brute, law-like facts, in a way that does not involve an implicit commitment to haecceitism and primitive identities. Nevertheless, it does appear to involve an unavoidable commitment to the reality of differences that are unobservable in principle: the theory that has only electrons 'congruent' to such a field coupling to W bosons and the theory that has only electrons 'incongruent' to such a field coupling to W bosons must be regarded as distinct theories, even though they are observationally distinguishable.

(Oliver Pooley, 'Handedness, parity violation, and reality of space', K. Brading, *Symmetries in*

AxB g en

(AxB).D>0

congruent

- World f(x)

(AxB).D>0
"left"

(AxB).D<0

Anti-congruent

- Mirror-world f(-x)

(AxB).D>0
"left"

Violatic of Princip of Sufficie reason

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….but how does this differ from a choice of coordinates?